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Art. VI.—*Sir William Edmond Logan.**

On the 22nd of June, at Castle Malgwyn, Llechyrd, South Wales, Canada's veteran geologist passed from his labors. For several years his health had been failing, and he felt more and more the need of rest and change of climate. Accordingly, in August, 1874, he crossed to the mother country, intending to pass the winter there, and then to return to his work in the spring. But rest and a more genial clime were unavailing, and now—kindest of friends, most indefatigable of workers for science and for his country—he is no more!

William Edmond Logan was born at Montreal, in 1798. He was of Scottish parentage, and his father, after a residence of many years in Canada, returned to Scotland, and purchased an estate near Stirling, known as Clarkstone. His education was begun at Mr. Skakel's school, in this city, and completed at the High School and University of Edingburgh.

On leaving college he betook himself to mercantile pursuits, and we find that in 1818 he entered the counting-house of his uncle, Mr. Hart Logan, of London. Here he remained for about ten years, and here, it is said, he first became fond of geology, making geological excursions into the country whenever opportunity offered.

In 1829 he paid a visit to Canada; but, returning the same year, took up his residence at Swansea, in South Wales, where he was appointed manager of a copper-smelting establishment, and of coal mines, in which an uncle of his was interested. In

* Obituary notice read before the Natural History Society of Montreal, October 25th, 1875.

1834, he made a tour through France and Spain, visiting many of the mines in the latter country, and making many observations on the geology of the regions through which he passed. In 1838, his uncle dying, Mr. Logan resigned his position at Swansea. But the nine years he spent here were well-spent years; for not only had he gained a practical knowledge of mining and metallurgy, which afterwards proved of the greatest value to him, but had done a large amount of very excellent geological work—work which caused Dr. Buckland, of Oxford, to say of him, "He is the most skillful geological surveyor of a coal-field I have ever known." During his stay at Swansea, he was an active worker for the interests of the Royal Institution of South Wales. He was Honorary Secretary and Curator of the geological department, and the Institution is indebted to him for valuable collections of minerals and metallurgical products, besides books, drawings and laboratory apparatus. The whole of his geological work in South Wales he placed gratuitously at the disposal of the Ordnance Geological Survey of Great Britain, and it was not only gladly accepted, but published "without alteration," and made the basis of future work in that region. Concerning it, Sir H. T. De la Beche afterwards wrote as follows:

"Prior to the appearance of the Geological Survey in that part of the country, Mr. W. E. Logan had carefully investigated it, and at the meeting of the British Association for the Advancement of Science, held at Liverpool in 1837, he exhibited a beautifully executed map of it.

"The work on this District being of an order so greatly superior to that usual with geologists, and corresponding, in the minuteness and accuracy of its detail, with the maps and sections executed by the Ordnance Geological Survey, we felt desirous of availing ourselves of it, when Mr. Logan most handsomely placed it at our disposal. Having verified this work with great care, we find it so excellent that we shall adopt it for that part of the country to which it relates, considering it but fair and proper that Mr. Logan should obtain that credit to which his labors so justly entitle him.

"His sections are all levelled and measured carefully with proper instruments, and his maps are executed with a precision only as yet employed, except in his case, on the Ordnance Geological Survey; it being considered essential on that survey, for the right progress of geology, and the applications to the useful purposes of life, that this accuracy and precision should be attained."

In 1840, Logan read a paper before the Geological Society of London, in which he explained, for the first time, the true relation of the *Stigmaria* underclays to the overlying beds of coal,

showing that the underclay was the soil in which the plants grew which were afterwards converted into coal. Of the 100 thick and thin coal-seams in the South Wales coal-field, he found that not a single one was without an underclay, and the inference appeared to be that there was some essential connection between the production of the one and the existence of the other. "To account," said he, "for the unfailing combination by drift, seems an unsatisfactory hypothesis; but whatever may be the mutual dependence of the phenomena, they give us reasonable grounds to suppose that in the *Stigmaria ficoides* we have the plant to which the earth is mainly indebted for those vast stores of fossil fuel which are now so indispensable to the comfort and prosperity of its inhabitants."

So much did he become interested in this subject that in the following year (1841) he crossed to America, and visited the coal-fields of Pennsylvania and Nova Scotia, in order to ascertain whether the same conditions existed there. Such he found to be the case; and in the following spring he read an interesting paper before the Geological Society, the object of which, to use his own words, "was to state the occurrence immediately below the coal-seams of America of the same *Stigmaria* beds as had been observed below those of South Wales, and to show the importance of this prevailing fact." Shortly after his return from America, he also visited coal-seams in the neighborhood of Falkirk, Scotland, there too, finding the *Stigmaria* clays beneath the coal.

It was during his visit to Nova Scotia, in 1841, that he discovered in the Lower Coal-measures of Horton Bluff the footprints of a reptilian animal—a discovery which, perhaps, failed to attract as much attention as it deserved, although it was the first instance in which any trace of reptiles had been detected as low down in the geological scale as the Carboniferous. The winter of 1841–42 was also spent in Canada, and the facts were obtained for a paper on the packing of ice in the St. Lawrence, which was subsequently read before the Geological Society of London.

Such, briefly, was the career of Logan previous to his appointment as Director of the Geological Survey of Canada. Already he had acquired a reputation in Britain as a geologist, and had given himself the best of trainings for the work upon which he was about to enter on this side of the Atlantic. But what was meantime passing in Canada? * * * *

"In July, 1841, in the first United Parliament, a petition from the Natural History Society of Montreal, praying for aid to carry out a systematic geological survey of the Province, was presented by Mr. B. Holmes. It was referred to a select committee consisting of Messrs. Holmes, Neilson, Quesnel, Mer-

rit, and the Hon. Mr. Killaly, but it was not reported on. A similar petition was presented by Mr. Black, from the Literary and Historical Society of Quebec, which was read. The government took up the matter, and on the motion of the Hon. B. Harrison, the sum of £1,500 sterling for the purpose of a survey was introduced into the estimates."*

Lord Sydenham dying in 1841, it fell to his successor, Sir Charles Bagot, to appoint a Provincial Geologist. Sir Charles referred the matter to Lord Stanley, Secretary of State for the Colonies, and His Lordship, on recommendation of Murchison, De la Beche, Sedgwick, and Buckland, offered the position to Mr. Logan in the spring of 1842.

Logan was now thoroughly in love with geology, and seeing in Canada the grandest of fields for original research, at once accepted. Still he well understood the difficulties which lay before him, and shortly afterwards addressed the following words to De la Beche: "You are aware that I have been appointed by the Provincial Government of Canada to make a Geological Survey of that Colony. The extent and nature of the territory will render the task a most laborious one; but I am fully prepared to spare no exertion of which I am capable to render the work, when it is completed, satisfactory to those who have instituted the examination and creditable to myself. * * No one knows better than yourself how difficult it would be for one person to work with effect in all the branches of so extensive a subject. To carry out the field-work with vigor, to reduce all the sections with the requisite degree of accuracy, and map the geographical distribution of the rocks, to collect minerals and fossils, and to analyze the one, and by laborious and extensive comparisons, to determine the geological age of the other, is quite impossible without a proper division of labor. * * In Canada, all the expensive means of palæontological comparison have yet to be brought together. There is no arranged collection of fossils, and no such thing as a geological library to refer to."

Arriving in Canada late in August, 1842, Logan devoted several months to making a preliminary examination of the country, and to collecting information with regard to the topographical work which had been accomplished. This was done entirely at his own expense. In December, he returned to England to fulfill engagements there, but came out again in the following spring. During his visit to the old country, he was so fortunate as to secure the services of Mr. Alexander Murray, a gentleman who afterwards proved himself an invaluable assistant and friend, and who has contributed largely to our knowledge of the geology of Canada, and, more recently, to that of Newfoundland.

*From Scobie's Canadian Almanac for 1851.

Reaching Halifax on the 20th of May, Logan spent several weeks in examining portions of the coal-fields of Nova Scotia and New Brunswick, and it was at this time that he made his section of the Coal Measures at the South Joggins, which, as has been truly said, is "a remarkable monument of his industry and powers of observation." It gives details of nearly the whole thickness of the coal formation of Nova Scotia, or 14,570 feet, including 76 beds of coal and 90 distinct *Stigmaria* underclays. Shortly after his visit to the Joggins, he wrote to a friend as follows: "I never before saw such a magnificent section as is there displayed. The rocks along the coast are laid bare for thirty miles, and every stratum can be touched and examined in nearly the whole distance. A considerable portion has a high angle of inclination, and the geological thickness thus brought to view is very great. I measured and registered every bed occurring in a horizontal distance of ten miles, taking the angle of dip all the way along." And again, in a letter to De la Beche written in the spring of 1844, referring to the Joggins section, he says: "Since my return from field-work, I have reduced all the measurements and made out a vertical column. It occupies fifty-four pages of foolscap, closely written, and you will be astonished at the details in it."

Reaching Gaspé early in July, the summer and autumn were spent in making an examination of the coast, while Mr. Murray was at work in the Upper Province, examining the country between Lakes Huron and Erie. The Gaspé peninsula had been selected by Mr. Logan as the field for his first operations, as it was thought that outlying patches of the Carboniferous might be found to exist there, and the government was especially anxious to ascertain whether there was any truth in the reported occurrence of coal.

The following season, the work in Gaspé was continued, the Director being this time accompanied by Mr. Murray, who, in 1845, again carried on the work, while Mr. Logan was engaged in explorations on the Upper Ottawa and Mattawan. Altogether, during the three seasons, 800 miles of the Gaspé coast were examined, and several sections made across the peninsula, from the St. Lawrence to Bay Chaleur. No coal was found, but many geological facts of importance were accumulated, and a large amount of topographical work accomplished in what was previously almost a *terra incognita*.

"Living the life of a savage, sleeping on the beach in a blanket sack with my feet to the fire, seldom taking my clothes off, eating salt pork and ship's biscuit, occasionally tormented by mosquitoes,"—such is the record which Logan has left us of his Gaspé life, the foretaste of what was to be endured for many years. From early dawn till dusk he paced or paddled, and yet

his work was not finished, for while his Indians—often his sole companions—smoked their pipes round the evening fire, he wrote his notes and plotted the day's measurements.

To give details of his work during the many remaining years of his life would be to write a book; and all that we can do here is to trace briefly what his movements were, at the same time calling special attention to those of his labors which have given him a world-wide fame.

The summer of 1846 found him studying the copper-bearing rocks of Lake Superior. These he showed to consist of two groups of strata, the "upper" and the "lower," the latter of which was seen at Thunder Bay to rest unconformably upon chloritic slates belonging to an older series, to which the name of Huronian was subsequently given. This older set of rocks, which he had already observed, in 1845, on Lake Temiscamang, he had ample opportunity of studying in 1848, when he devoted several months to an examination of the Canadian coast and islands of Lake Huron, where the formation attains—as shown by Murray—a thickness of 18,000 feet.

The seasons of 1847 and 1849, and a portion of that of 1848, were employed in studying the rocks of the Eastern Townships. Part of these were shown to be a prolongation of the Green Mountains of Vermont, and to consist of altered Silurian strata instead of "Primary strata," as was previously supposed by American geologists. In 1849 also, a short time was spent in an examination of the rocks about Bay St. Paul and Murray Bay, where coal had been reported to exist. The member for Saguenay County had previously made application to the Legislature for means to carry on boring operations in the vicinity of Bay St. Paul, but before his request was granted it was deemed advisable to obtain the opinion of the Provincial Geologist. By this means the Government was saved a large and useless expenditure of money.

In 1850 an examination was made of the gold-bearing drift of the Chaudière, and the auriferous district found to extend over an area of between 3,000 and 4,000 square miles. Most of the year, however, was devoted to the collection of specimens for the London Exhibition of 1851, at which Mr. Logan acted as Juror. His visit to England at this time must have been for him an agreeable change. After a lapse of eight years to meet again with men like De la Beche, Murchison and Lyell, to hear from their own lips of the strides which science had been making, and in turn to tell of all that he had himself seen and done: surely this was a treat that none but the scientific man can understand who has long been well-nigh deprived of the society of brother scientists. For him, however, there was little relaxation from labor, for he toiled early and late in order that the

Canadian minerals might be displayed to the best advantage. And every one knows the result—the collection elicited universal admiration, and Mr. Logan received a highly complimentary letter of thanks from the Prince Consort, and was elected a Fellow of the Royal Society, his name having been proposed by Sir Roderick Murchison.

Returning to Canada in August, before the close of the Exhibition, his explorations were renewed with undiminished vigor, and the remainder of the season devoted to an examination of the rocks in the county of Beauharnois, where the Potsdam sandstones had afforded those curious tracks of crustaceans to which Owen gave the name of Protichnites, and to a further study of the Chaudière gold region. During the winter he again visited England to attend to the distribution of a portion of the Exhibition collection which was to be left there, and to see to the return of the remainder.

In 1852 an examination was made of a strip of country on the north side of the St. Lawrence, extending from Montreal to Cape Tourmente below Quebec. The distribution of the fossiliferous rocks was accurately determined, and several excursions were made into the hilly "metamorphic country" to the north. In his report on this season's operations, published in 1854, Logan for the first time designated the rocks comprising these hills as the "Laurentian series," substituting this for "metamorphic series," the name which he had previously employed, but which, as he says, is applicable to any series of rocks in an altered condition.

The following season was spent among the Laurentian hills of Grenville and the adjoining townships, a field which proved so attractive that he afterward returned to it in 1856 and 1858. Nearly the whole of 1854 was occupied in making preparations for the Exhibition which was to take place at Paris in the following year, and to which Mr. Logan was to go as one of the Canadian Commissioners. It was in the autumn of 1854 also, that a select committee was appointed by the Canadian Government to inquire into the best method of making the information acquired by the Geological Survey more readily accessible to the public. A lengthy report on the subject—indeed on the entire working of the Survey—was published, and the evidence which it contains is of a most flattering character, both as regards the Director and those associated with him.

Then came the Paris Exhibition of 1855, at which the representation of the economic minerals of Canada was so complete and the arrangement so admirable that the collection attracted universal attention. This in itself Logan would have regarded as amply repaying him for his trouble; but greater honor was in store for him. The Imperial Commission presented him with

the grand gold medal of honor, and the Emperor of the French made him a Chevalier of the Legion of Honor. Early in the following year (1856) he was knighted by Queen Victoria, and received from the Geological Society of London the Wollaston Palladium Medal in recognition of his distinguished labors in geology. Long previous he had won the confidence and esteem of his fellow-countrymen in Canada, but this seemed to be a fitting time to testify to him their appreciation of his worth. Accordingly, on his return to Montreal, the citizens presented him with a testimonial on which were engraved the words:

"In commemoration of his long and useful services as Provincial Geologist in Canada, and especially his valuable services in connection with the Exhibition of all Nations in London in 1851, and in Paris in 1855, by which he not only obtained for himself higher honor and more extended reputation, but largely contributed in making known the natural resources of his native country."

The Natural History Society of Montreal presented him with an address, and made him an honorary member, while the members of the Canadian Institute of Toronto, of which Sir William was the first President, had his protrait painted and hung up in their hall. They also presented him with an address expressive of their affectionate esteem and respect. Sir William's reply to this was so full of feeling, and so highly characteristic, that we give a portion of it: "Whatever distinctions," said he "may be bestowed on us at a distance, it is upon the respect, esteem, and confidence shown us at home, that our happiness and satisfaction must chiefly depend. I can assure you with sincerity that the honor conferred upon me, when you elected me the first President of the Institute, was one highly prized, although the circumstances of a distant domicile, and the intent pursuit of the investigations with which I am charged, rendered it extremely difficult for me to be of much use in your proceedings. . . . . It is a fortunate circumstance for me that my name should be connected with an act of grace on the part of Her Majesty, which serves to confirm your feeling in regard to the fact that as Canadians we enjoy a full share in the honors and privileges of British subjects. And I am proud to think that it was perhaps more because I was a Canadian, in whom the inhabitants of the Province had reposed some trust, that the honor which has been conferred upon me by Her Majesty was so easily obtained. That I am proud of the honors which have been bestowed upon me by the Emperor of France, in respect to my geological labors, and also by my brother geologists in England, there can be no doubt. But I have striven for these honors because I have considered they would tend to promote the confidence which the inhabitants of the Province have

reposed in me, in my endeavors to develop the truth in regard to the mineral resources of the Province; and in this work none could have been more interested in my success than the members of this Institute."*

In August, 1857, the American Association for the Advancement of Science held its annual meeting in Montreal, and for several months previous Sir William was hard at work getting his museum in readiness to receive his brother geologists. Owing largely to his untiring exertions, the meeting was a most successful one. He himself read two interesting papers, one on the "Huronian and Laurentian Series of Canada," and another on the "Sub-division of the Laurentian Rocks of Canada" After the business of the Association was concluded, accompanied by Professor Ramsay, who had come over to represent the Geological Society of London, and Professor Hall, he made a Geological tour through New York State. Returning from this trip, he spent the autumn months among the Laurentian Rocks of Grenville. Here too, as already mentioned, he continued to work during the season of 1858.

For several years after this, his time was much taken up with the preparation and publication of the *Geology of Canada* and its accompanying Atlas, the former of which appeared in 1863, and the latter in 1865. Before these could be completed, however, many facts had to be added to the stock already obtained, and besides a large amount of geological work among the Laurentian rocks of Grenville and the rocks of the Eastern Townships, a personal examination of many parts of the country, as well as of portions of the New England States, was rendered necessary.

In 1862, Sir William was again present, in the capacity of Juror, at the London International Exhibition, and again displayed a large and interesting collection of economic minerals. Another opportunity of seeing his scientific friends in Britain was also afforded him in 1864, when he went to London to superintend the engraving of the Atlas already mentioned. In 1866, a geological collection was again prepared for the Paris Exhibition of 1867, and Sir William worked so closely in getting up a geological map to accompany it that he is said to have nearly ruined his eyesight. 1868 found him once more on this side of the Atlantic, hard at work in the Pictou coal-field, and the results of this season's work constitute the last of his reports. In 1869, he resigned his appointment to Mr. Selwyn, the present Director of the Survey.

The few remaining years of his life were occupied chiefly with a study of the rocks of the Eastern Townships and portions of New England: but, unfortunately, the conclusions at which he arrived concerning them were not published.

* Can. Journal, New Series, vol. i, p. 404.

No man has done as much as Sir William Logan to bring Canada before the notice of the outside world, and no man is more deserving of being held in remembrance by the people. Just as statesmen or generals have risen up at the moment of greatest need to frame laws or fight battles for their country, so Sir William appeared to reveal to us the hidden treasures of Nature, just at a time when Canada needed to know her wealth in order to appreciate her greatness For rising nations require to know what their resources are. He possessed rare qualities—qualities, which, combined, eminently fitted him for his work. He was strong in body, of active mind, industrious and doggedly persevering, painstaking, a lover of truth, generous, possessed of the keenest knowledge of human nature, sound in judgment, but always cautious in expressing an opinion.

He belonged to that school of geologists—unfortunately not so numerously represented as it ought to be—whose motto is, "Facts, then theories," and was wholly above rasping down facts to make them fit theories. As a consequence, he rarely had to un-say what was once said; and this is why he so thoroughly gained the public confidence. So long as he felt that he was in the right, he held to his own views as tenaciously as did ever any true Scot; but if shown to be in the wrong, he knew how to surrender gracefully.

Those who have clambered with him over our log-strewn Laurentian hills know well what were his powers of endurance. He never seemed to tire, never found the days long enough. His field-books are models of carefulness, replete with details, and serve as an example of the painstaking way in which he did all his work. They were written in pencil, but regularly inked in at night, when the camp fire was often his only light. In addition to his field-book proper, he frequently kept a diary, and delighted to jot down little every-day occurrences, or sketch objects of interest—for the hand that could so well wield a hammer, could also guide a pencil and produce drawings of no mean artistic skill. His descriptions of his backwoods experiences are often very amusing, and we cannot resist giving a specimen. He had been traveling through the forest for two months and had suddenly come upon the house of a settler called Barton, whose good wife was justly alarmed when Sir William and party entered her dwelling. Sir William describes his appearance, on this occasion, as follows:—"We are all pretty-looking figures. I fancy I cut the nearest resemblance to a scarecrow. What with hair matted with spruce gum, a beard three months old, red, with two patches of white on one side, a pair of cracked spectacles, a red flannel shirt, a waistcoat with patches on the left pocket,—where some sulphuric acid, which I carry in a small vial to try for the presence of lime in the rocks, had

leaked through,—a jacket of moleskin, shining with grease, and trowsers patched on one knee in four places, and with a burnt hole in the other: with beef boots—Canada boots, as they are called—torn and roughened all over with scraping on the stumps and branches of trees, and patched on the legs with sundry pieces of leather of divers colors; a broad-brimmed and round-topped hat, once white, but now no color, and battered into all shapes. With all these adornments, I am not surprised that Mrs. Barton, speaking of her children, and saying that here was "a little fellow frightened of nothing on earth," should qualify the expression by saying, "but I think he's a little scared at *you*, Sir."

It was not alone in the field that Sir William was busy. His office work was often most arduous, and during the earlier years of his directorship, in addition to preparing his annual report, he even kept the accounts, entering every item of expenditure, so that he could at any time show exactly how every penny of the public money placed at his disposal had been spent. He also tells us that, with his own hands, he made, at that time, four manuscript copies of the Annual Report of Progress, often reaching more than one hundred printed pages—one copy for the Government, one for the House of Assembly, one for the Legislative Council, and one for the printer.

His manner of living was simple as it was solitary. Like his four brothers, he never married, nor does he seem to have formed many intimate friendships. Still every one who knew him loved him and respected him, and if you go the length and breadth of all the land, you will everywhere hear his praises, alike from rich and poor.

He peculiarly possessed the power of inspiring others with his own enthusiasm; not only those in his employ, but even uneducated farmers and backwoodsmen—men who, as a rule, are rather sceptical about the advantages to be derived from geology.

Though possessed of private means, he spent little upon himself; not that he was parsimonious, but he cared not for fashion or luxury. But with him Science never pleaded her needs in vain. The first grant of the Legislature, to make a geological survey of the Colonies, was £1,500—an amount which, Sir William quaintly remarked, was but a drop of what would be required to float him over twenty-five degrees of longitude and ten of latitude. This was, of course, very soon spent, and not only this, but at the end of the second year the Survey was £800 in his debt, and he had no guarantee whatever that his money would be returned to him. Since then the Survey has been constantly indebted to him for books, instruments, and other aids, and the building on St. James street, now used for office purposes, was built by him, two years ago, and rented to the

Government for about half the amount which he could have obtained from other tenants. To Logan also, McGill University owes much; for, in 1864, he founded and endowed the "Logan Gold Medal" for an honor course in geology and natural science, and, in 1871, gave $19,000, which, together with $1,000 given by his brother, the late Mr. Hart Logan, forms the endowment of the "Logan Chair of Geology."

Since resigning his position as Director of the Geological Survey, he has carried on explorations at his own expense, and, at the time of his death, arrangements had been nearly completed for putting down a bore-hole in the Eastern Townships, at a cost of $8,000; as he thought that this would enable him to prove the truth of his views with regard to the age of the metamorphic rocks there. . . . .

Sir William was the first to give us any definite information about those wondrous old Laurentian rocks which form the backbone of our continent. He showed us that they were older than the Huronian, and that they consisted of a great series of metamorphosed sedimentary rocks, which are divisible into two unconformable groups, with a combined thickness of not less than 30,000 feet. The great beds of limestone which he found in the lower series, the plumbago, the iron ores, the metallic sulphurets, all seem to point to the existence of life in the Laurentian days; but the discovery of *Eozoon Canadense* made conjecture give place to certainty. Now we *know* that the world of that far-off time was not a lifeless world. Life, whatever that may be, had been joined to matter.

The first specimens of *Eozoon* were found by Dr. James Wilson, of Perth; but at the time of their discovery were regarded merely as minerals. In 1858, however, Mr. J. McMullen, of the Geological Survey, discovered other specimens, the organic origin of which so struck Sir William that in the following year—four years before their true structure and affinities were determined by Dawson and Carpenter—he even exhibited them as fossils at the meeting of the American Association.

In widely extending our knowledge of the early geological history of the earth, Sir William has done a great work; indeed this may be regarded as his greatest work. Its importance has everywhere been recognized, and the name Laurentian, which he chose for the rocks at the bottom of the geological scale in America, has crossed the Atlantic, and is now applied to the homotaxial rocks of Europe. Sir Roderick Murchison, who dedicated the fourth edition of "Siluria" to Sir William Logan, even substituted Laurentian for "Fundamental Gneiss," the name which he had given to the rocks of the West Highlands of Scotland. "I at first," says Murchison, "termed them 'Fundamental Gneiss,' and soon after, following my distinguished friend

Sir William Logan, I applied to them his term, 'Laurentian,' and thus clearly distinguished them from the younger gneissic and micaceous crystalline rocks of the Central and Eastern Highlands, which were classed as metamorphosed Lower Silurian."

Logan was not a voluminous writer, and during the later years of his life writing was a great effort to him. Occasional papers from his pen have appeared in the *Transactions of the Geological Society* of London, in the *Canadian Naturalist* and the *Canadian Journal*, and some of these have already been referred to; but most of what he has written is to be found in the *Reports of Progress* annually submitted to the Government, and in that invaluable book, the *Geology of Canada*, which is, to a large extent, a digest of what is contained in the reports published previous to 1863. He sometimes expressed himself quaintly, but everything he wrote is clear and exceedingly concise.

In addition to being a Fellow of the Royal Society and of the Geological Societies of London and Paris, he was a member of numerous other learned societies both in Europe and America. At the time of his death, and for many years previous, he was one of our Vice-Presidents; but though frequently solicited to accept the office of President, he always declined,—not on account of any lack of interest in the Society, but he felt his time was too fully occupied to permit of his successfully discharging the Presidential duties. We have already alluded to some of the medals which were awarded to him; but it may be mentioned that altogether he was the recipient of more than twenty, including two from the Royal Society.

And now, in concluding, let me say to you, my friends, if you would do honor to the memory of that noble old man, who fought so long, so bravely, for his country, for science, for you, then honor the cause for which he fought: strive with all your might to advance the interests of that cause, and to raise up a superstructure befitting the solid foundation which Logan has laid. He himself even hoped to build the superstructure; but his anticipations were not realized, for life was not long enough, and we must take up the mantle which he has dropped.

B. J. HARRINGTON.

ART. VII.—*On Recent Researches in Sound;* by WM. B. TAYLOR.

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IV.

THE communication of Professor Reynolds "On the Refraction of Sound by the Atmosphere," is in two parts; the first of which considers "The effect of Wind upon Sound," and the second part "The effect of variations of Temperature." The experiments were all made in "a flat meadow of considerable extent;" and the apparatus employed "consisted of an electrical bell mounted on a case containing a battery. The bell was placed horizontally on the top of the case, so that it could be heard equally well in all directions; and when standing on the ground, the bell was one foot above the surface." An anemometer was also used to determine the velocity of the wind. (Proceedings of the Royal Society; republished in the L. E. D. Phil. Mag., for July, 1875, vol. l, p. 67.)

The experiments were made on four different days, the 6th, 9th, 10th, and 11th of March, 1874; and on the last two days the ground was covered with snow, which furnished an opportunity of comparing the effect of different surfaces on the range of Sound. Additional experiments were made on the 14th of March.

[1.] "On all occasions the effect of wind seems to be rather against distance than against distinctness. Sounds heard to windward [that is *against* the wind] are for the most part heard with their full distinctness; and there is only a comparatively small margin between that point at which the sound is perceptibly diminished, and that at which it ceases to be audible." (Phil. Mag., p. 63.)

[2.] The sound of the alarm-bell was always heard "farther with the wind than at right-angles to its direction; [contrary to the old observation of De La Roche in 1816,—which was obviously an exceptional one;] and when the wind was at all strong, the range with the wind was more than double that at right angles. . . . . *With* the wind, over the grass the sound could be heard 140 yards, and over the snow 360 yards, either with the head lifted or on the ground; whereas at right-angles to the wind, on all occasions the range was extended by raising either the observer or the bell." (p. 68.)

[3.] When the wind was light the sound beyond the distance of 20 yards, was much less audible at the ground than a few feet above it; and when inaudible in every direction at standing height, the sound could be distinctly recovered by mounting a tree. The same result was obtained by raising the alarm-bell

upon a post 4 feet high; which while materially increasing the range of the sound—even in the direction of the slight wind, in all other directions doubled the range. This is explained by Professor Reynolds, by the continual waste and destruction of the sound waves which pass along the rough surface of the ground or grass, causing the waves immediately above to diverge continually downward, to be in like manner absorbed; the effect of which is to gradually weaken the sound more and more, as the waves proceed; so that even "when there is no wind, the distant sounds which pass above us are more intense than those we hear." (p. 68.)

[4.] Whatever therefore tends to gradually bend downward the sound rays will increase their sensible range. Professor Reynolds found by observations with the anemometer that the velocity of the wind increased from the ground upward; (pp. 63, 64) and hence it must give greater rapidity to the upper portion of the sound waves in the direction in which it is blowing and cause their impulses to continually tip downward. "This was observed to be the case on all occasions. In the direction of the wind when it was strong, the sound could be heard as well with the head on the ground as when raised, even when in a hollow with the bell hidden from view by the slope of the ground; and no advantage whatever was gained either by ascending to an elevation, or raising the bell." (p. 68.)

[5.] "Elevation was found to affect the range of sound against the wind in a much more marked manner than at right-angles. Over the grass no sound could be heard with the head on the ground at 20 yards from the bell, and at 30 yards it was lost with the head 3 feet from the ground, and its full intensity was lost when standing erect at 30 yards. At 70 yards when standing erect the sound was lost at long intervals, and was only faintly heard even then; but it became continuous again when the ear was raised 9 feet from the ground, and it reached its full intensity at an elevation of 12 feet." (p. 69.) The same results were obtained with snow on the ground, excepting that the sound was heard somewhat lower, being less dissipated or absorbed by the surface contact. At 160 yards the bell was inaudible—even at an elevation of 25 feet, and the sound was supposed to be hopelessly lost; but at a further elevation of 33 feet from the ground, it was again heard; while at 5 feet lower it was lost. At the proper elevation the sound appeared to be as well heard against the wind as with it, at the same distance. These last two observations very strikingly correspond with and confirm the observations of Henry [3], and [4].

[6.] "The least raising of the bell was followed by a considerable intensifying of the sound;" and while it could be heard only 70 yards when resting on the ground, (i. e., one foot

high), when set on a post 5 feet high, it could be heard 160 yards, or more than twice the distance,—the sound-beams evidently rising faster at or near the ground, than they do higher up. (p. 69.) "The intensity of the sound invariably seemed to waver, and as one approached the bell from the windward side, the sound did not intensify uniformly or gradually, but by fits or jerks." This is supposed to be the result of the more or less curved sound rays crossing each other at a small angle and producing an "interference." (p. 70.)

A subsequent experiment was made on the 14th of March, during a strong west wind, its velocity at an elevation of 12 feet being 37 feet per second, at 8 feet, 33 per second, and at one foot from the ground (there being no snow on the grass) 17 feet per second. While the results as to varying range fully confirmed the previous experiments, the raising of the bell caused the sound to be heard even better against the wind than in the direction of the wind. (p. 71.) This curious circumstance is explained by Professor Reynolds as "due to the fact that the *variation* in the velocity of the air is much greater near the ground, than at a few feet above it;" and "when the bell is raised the rays of sound which proceed horizontally will be much less bent or turned up than those which go down to the ground; and consequently after proceeding some distance these rays will meet or cross, and if the head be at this point they will both fall on the ear together, causing a sound of double intensity. It is this crossing of the rays also which for the most part causes the interference" just mentioned. (p. 71.)

Professor Reynolds concludes that "these experiments establish three things with regard to the transmission of sound: 1. That when there is no wind, sound proceeding over a rough surface is more intense above than below. 2. That as long as the velocity of the wind is greater above than below, sound is lifted up to windward and is not destroyed. 3. That under the same circumstances it is brought down to leeward, and hence its range extended at the surface of the ground. These experiments also show that there is less variation in the velocity of the wind over a smooth surface than over a rough one. It seems to me that these facts fully confirm the hypothesis propounded by Prof. Stokes; that they place the action of wind beyond question; and that they afford explanations of many of the anomalous cases that have been observed." (p. 71.)

[7.] In regard to the second part of the communication, treating of the effect of Temperature differences in refracting sound, Professor Reynolds shows that as "every degree of temperature between 32° and 70° adds approximately one foot per second to the velocity of sound," there must necessarily be an upward flexure of the rays, whenever by reason of any consid-

erable increase of temperature in the lower strata of the air, the lower portion of the sound waves is projected in advance of the upper portion. (p. 71.) Atmospheric vapor also, though exercising but little direct influence on the velocity of sound, "nevertheless plays an important part in the phenomena under consideration; for it gives to the air a much greater power of radiating and absorbing heat, and thus renders it much more susceptible of changes in the action of the sun. . . . . It is a well-known fact that the temperature of the air diminishes as we proceed upward, and that it also contains less vapor. Hence it follows that, as a rule, the waves of sound must travel faster below than they do above, and thus be refracted or turned upward." (p. 72)

The variation of temperature will be greatest in a quiet atmosphere when the sun is shining. The report of Mr. Glaisher "On eight Balloon Ascents in 1862" showed that "The decline of temperature [upward] near the earth with a partially clear sky is nearly double that with a cloudy sky."* "During the night the variations are less than during the day. This reasoning at once suggested an explanation of the well-known fact that sounds are less intense during the day than at night. This is a matter of common observation, and has been the subject of scientific enquiry." (p. 73.) The opinion must here be hazarded that this familiar phenomenon has first received its true and satisfactory explanation from Professor Reynolds.

Assuming that for a few hundred feet upward, the diminution of temperature on a clear summer day is 1° for each hundred feet, a horizontal sound-ray would be bent up in an arc having a radius of about 20 miles. From a cliff 235 feet high, a sound should be audible from $1\frac{1}{2}$ to 2 miles on the sea, and the ray should then begin to rise above the observer's head. This is shown to accord very closely with the observation of Tyndall [6]. Professor Reynolds after quoting the observation at length, remarks: "Here we see that the very conditions which actually diminished the range of the sound were precisely those which would cause the greatest lifting of the waves. And it may be noticed that these facts were observed and recorded by Professor Tyndall with his mind altogether unbiased with any thought of establishing this hypothesis. He was looking for an explanation in quite another direction. Had it not been so he would probably have ascended the mast and thus

* Mr. Glaisher remarks: "From these results we may conclude that in a cloudy state of the sky, the decline of temperature is nearly uniform up to the clouds; that with a clear sky the greatest change is near the earth, being a decline of 1° in less than 100 feet, gradually decreasing as in the general law indicated in the preceding section, till it requires 300 feet at the height of 5,000 feet, for a change of 1° of temperature." (Rep. Brit. Assoc, 1862, p. 462.)

found whether or not the sound was all the time passing over his head. On the worst day an ascent of 30 feet should have extended the range nearly one quarter of a mile." (Phil. Mag., p. 76.)

V.

The instructive result, brought into view by the foregoing summaries, is that the differences noticed are essentially those of interpretation, and not to any important extent, of observation: an illustration if any were needed, of the high and rare order of imaginative insight requisite to the successful investigation of the more recondite operations of natural law. The differing actions of acoustic reflection and acoustic refraction suggested by the ingenious hypotheses of Humboldt and of Stokes, and espoused respectively by Tyndall and Henry, are probably both operative but their relative importance has yet to be established. It is certain, as already indicated, that some of the phenomena observed lie quite beyond the reach of the acoustic cloud hypothesis.

A particularly interesting case which is claimed with equal confidence for either theory, is the remarkable observation of General Duane, that at Portland, Maine, the steam whistle on Cape Elizabeth, nine miles distant, "can always be distinctly heard" with "the wind blowing a gale directly *toward* the whistle" or against the sound. (L. H. Rep., p. 100.) At Portland Head, about midway between this fog-whistle and the point of observation is another signal,—a Daboll trumpet. While both these signals are better heard with an adverse wind ("a heavy northeast snow storm") than at other times, yet "as the wind increases in force, the sound of the nearer instrument—the trumpet—*diminishes*, but the whistle becomes *more distinct*." (Rep., p. 92.) The abnormal influence of the wind in reversing the order of these two signals is not the least surprising feature of the general phenomenon.

Professor Tyndall believes that this curious observation only "proves the snow-laden air from the northeast to be a highly homogeneous medium;" (Sound, Preface, p. 19,) the intervening air at other times being acoustically less transparent.

Professor Henry supposes "that during the continuance of the storm, while the wind was blowing from the northeast at the surface, there was a current of equal or greater intensity blowing in an opposite direction above, by which the sound was carried in direct opposition to the direction of the surface current;" (Rep., p. 92)—somewhat in the nature of a vertical cyclone. He adds: "The existence of such an upper current is in accordance with the hypothesis of the character of a northeast storm, which sometimes rages for several days at a given

point on the coast without being felt more than a few miles in the interior, the air continuously flowing in below and going out above. Indeed in such cases a break in the lower clouds reveals the fact of the existence above of a rapid current in the opposite direction." (p. 92.)

Professor Henry's attention had been directed to this point as early as 1865, by discovering that a signal was audible against the wind at the mast-head of a vessel, after ceasing to be audible on deck: Obs. [4]. "This remarkable fact at first suggested the idea that sound was more readily conveyed by the upper current of air than the lower, and this appeared to be in accordance with the following statement of Captain Keeney, who is commander of one of the light-house vessels, and has been for a long time on the banks of Newfoundland in the occupation of fishing: 'When the fishermen in the morning hear the sound of the surf to leeward, or from a point toward which the wind is blowing, they take this as an infallible indication that in the course of from one to five hours the wind will change to the opposite direction from which it is blowing at the time.' The same statement was made to me by the intelligent keeper of the fog-signal at Block Island. In these cases it would appear that the wind had already changed direction above, and was thus transmitting the sound in an opposite direction to that of the wind at the surface of the earth." (Rep., p. 92.) The full significance of this idea however was not apprehended until the hypothesis of Professor Stokes (already alluded to) was taken up and considered. This appeared to furnish a satisfactory explanation of the observed effect of an upper current,—not on the actual range, but on the *direction* of the sound waves

Professor Tyndall thus comments on the rival hypothesis of Professor Henry: "In the higher regions of the atmosphere he places an ideal wind, blowing in a direction opposed to the real one, which *always* accompanies the latter, and which more than neutralizes its action. In speculating thus he bases himself on the reasoning of Professor Stokes, according to which a sound-wave moving against the wind is tilted upward. The upper and opposing wind is invented for the purpose of tilting again the already lifted sound-wave downward." (Pref. to Sound, pp. 19, 20.)

The word "invented" is scarcely the most appropriate term for an hypothesis derived from such patient research and careful induction. While in the case considered, the reversed upper wind of a local circulation is rendered so probable by the circumstances presented, it is proper to remark that this condition is not at all essential to the refraction doctrine. The hypothesis of Professor Stokes by no means assumes that "a

sound-wave moving against the wind is tilted upward." (Rep. Brit. Assoc., 1857, pp. 22, 23, of Abstracts.) An opposing wind exercises no sensible influence on either the velocity or the range of sound, nor (if *uniform*) on the direction of sound. Ordinarily indeed, a wind (which may be likened to an aerial river) is retarded at the earth precisely as the current of a stream is, over its bed.* When, however, the mouth of the aerial chimney of ascent is low, it may very well happen that the lower current of air (excepting immediately at the surface of the earth) is considerably swifter than the successive layers of wind above it; and in such a case the effect of the opposing wind will be not to tilt upward the sound-beam, but to tilt it downward. In like manner a "favoring" wind, if more sluggish above, will tilt the sound-beam upward, and thus prove unfavorable to its audibility. In short, the postulate required for acoustic refraction is simply that there shall be a *difference* of amount between the upper and the lower currents of wind. And as this condition is certainly not an unusual one, we have here apparently a true and satisfactory account of the seeming anomalies of sound with reference to the influence of the wind.

But if the natural tendency of a mere diminution of velocity in the upper strata of an adverse wind is thus to bend an advancing sound downward, "a precisely similar effect" as Professor Henry has well remarked, "will be the result but perhaps in a considerably greater degree, in case an upper current is moving in an opposite direction to the lower, when the latter is adverse to the sound." (Rep., p. 107.) In September, 1874, when a signal near Sandy Hook, N. J., was observed to be audible at a greater distance against the afternoon sea-breeze than with it, Professor Henry ascertained by the employment of small toy balloons, that the upper current was opposed to the lower one, and in the direction of the maximum sound range: Obs [11.] He was enabled thus to demonstrate experimentally the reality of the "ideal wind" which had been so confidently accepted before, from other conspiring intimations.

The critical commentary above cited, which postulates for this doctrine of acoustic refraction the super-position of "an ideal wind blowing in a direction opposite to the real one," as a condition "which more than *neutralizes* its action," quite fails to apprehend its true import. No action analogous to "neutralization" is assumed by the doctrine. There is no solution

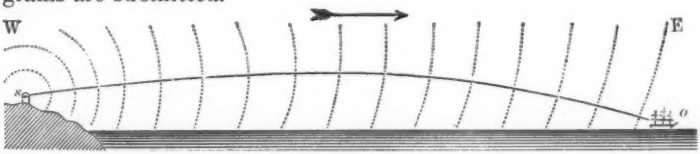
* Professor Henry determined by experiment in 1865, when the velocity of the wind was not more than six miles per hour, that the speed of the clouds as indicated by their moving shadows, was several times this rate. (L. H. Rep., p. 93.) And Professor Reynolds in 1874, by observations with the anemometer, ascertained that near the ground the retardation of the wind rapidly increased; so that the lower sound rays move more nearly in the arc of a parabola, than of a circle. (Phil. Mag., pp. 64 and 70.)

of continuity between opposing currents; but every gradation of movement in each successive intermediate stratum. And as it is wholly improbable that the sound-beam *which reaches the observer's ear*, ever passes high enough to approach the upper "ideal wind," nothing is neutralized. Obedient to the law of instantaneous resultants, the beam of acoustic impulse presses on ever at right angles to the wave-surface which is conditioned by compounded factors.

As wide of the mark is the supposition that the upper and opposing "ideal wind" is "for the purpose of tilting again the already lifted sound-wave, downward." As has been just contended, the one wind is as incapable of depressing the sound-wave, as the other is of lifting it.

The misconception culminates in the objection that "Professor Henry does not explain how the sound-wave *re-crosses* the hostile lower current, nor does he give any definite notion of the conditions under which it can be shown that it will reach the observer." (Loc. cit., p. 20.) There *is* no "hostile lower current," since as above pointed out, an opposite wind may be just as favorable to the propagation of sound, as a concurrent one.

To give, however, a more definite notion of the conditions under which it can be shown that the sound-wave will reach the observer without crossing currents, the accompanying diagrams are submitted.

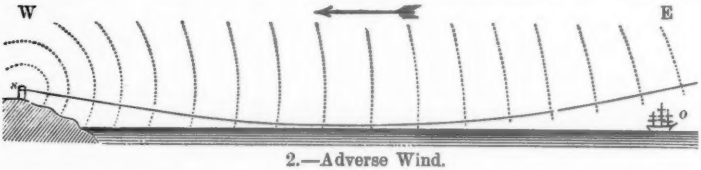


1.—Favoring Wind.

Fig. 1 exhibits the more ordinary effect of a *favorable* wind in depressing the beam of sound: *s* being the signal-station, and *o* the point of observation; the wind blowing from *W.* to *E.* As the spheroidal wave-faces become more pressed forward above by the freer wind (assuming it to be retarded at the surface by friction), and as the direction of the acoustic beam is constantly normal to the successive aerial surfaces of impact, it follows that very minute differences of concentricity in the successive waves, will by constant accumulation gradually bend the line of dynamic effect downward, as shown in the sketch on a very exaggerated scale. Of the sound rays below the line represented, some will by reflection from the sea, reach the observer's ear and thus increase the sound.

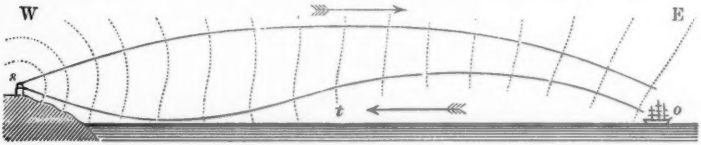
Fig. 2 represents the ordinary effect of an *opposing* wind here blowing from *E.* to *W.* The wave faces being more resisted

above by the freer contrary wind (assuming as before a surface retardation), the sound-beams are curved upward, and the lowest ray that can reach the distance of the observer at *o*, is that which touching the surface of the sea is gradually so tilted up-



2.—Adverse Wind.

ward that it passes above the ear of the listener, leaving him practically in an acoustic shadow; very much as an observer on the deck of a vessel when losing the sight of the hull of another vessel ten miles off, by reason of the interposed convexity of the ocean, stands in the *optical* shadow of the earth. In both cases if the conditions favor, the boundary of the shadow may be re-crossed by ascending from the deck to the mast-head, and the sight or the sound-beam thus regained.



3.—Compound Wind.

Fig. 3 represents the disturbing effect of a lower contrary wind with an opposite wind above. In this case the principal result will be a depression of the sound-beam as in fig. 1, but more strongly marked, as the differences of motion as we ascend will be more rapid. Attending this action, however, there will probably be some lagging of the lower stratum of the adverse wind by reason of the surface friction; the tendency of which will be to slightly distort the lower sound radiations, by giving them a reverse or serpentine curvature. The upper rays of sound would probably have only a single declining curvature, similar to that shown in fig. 1.

One result of this condition of the *locus* of the *normals* (to use a mathematical phrase) would be to make the sound less audible (or possibly sometimes inaudible) at a point (as at *t*) midway between the two stations. This hypothetical case of compound refraction would appear to offer a plausible explanation, not only of the paradox of a nearer trumpet-sound being diminished in power by the wind which increased the effect of a more distant whistle, but also of the puzzling "belt" of inaudibility previously noticed. Duane [D], and Henry [8].

Numerous other cases might be represented by diagrams, as of a sound being hindered or tilted upward by a concurrent wind of unequal velocity, or downward by an opposing wind of similar character, and of the various permutations of differing currents in oblique directions; to which might be added various resultants of unequal motion producing *lateral* refraction, but this is unnecessary. Enough has been said, it is hoped, to clear from popular misapprehension, the admirable hypothesis of Professor Stokes, raised by the equally admirable investigations of Professor Henry, to the rank of a "theory;" and to show that it has a real and demonstrated basis, or in other words that it is a *vera causa*. The question of its sufficiency lies entirely within the grasp of mathematical discussion; but a long series of accurate and comprehensive observations will yet be required to discover its full compass of practical result, and to determine its precise limit of capacity in subjugating the "abnormal phenomena" of sound.

ART. VIII.—*Studies on Magnetic Distribution*; by HENRY A. ROWLAND, of the Johns Hopkins University, Baltimore.

(Continued from page 29.)

VI.

M. JAMIN, in his recent experiments on magnetic distribution, has obtained some very interesting results, although I have shown his method to be very defective. In his experiments on iron bars magnetized at one end, he finds the formula ϵ^{rL} to apply to long ones as I have done. Now it might be argued that as the two methods *apparently* give the same result, they must be equally correct. But let us assume that the attraction of his piece of soft iron F varied as some unknown power n of the surface-density δ. Then we find

$$F = C\epsilon^{nrL},$$

which shows that the attractive force or any power of that force can be represented by a logarithmic curve, though not by the same one. Hence the error introduced by M. Jamin's method is insidious and not easily detected, though it is none the less hurtful and misleading, but rather the more so.

However, his results with respect to what he calls the normal magnet* are to some extent independent of these errors; and we may now consider them.

Thus, in explaining the effect of placing hardened steel

* "On the Theory of Normal magnets," *Comptes Rendus*, March 31, 1873, translated in Phil. Mag., June, 1873.

plates on one another, he says: "Quand on superpose deux lames aimantées pareilles, les courbes qui représentent les valeurs de F (the attractive force on the piece of soft iron) s'elévent, parce que le magnétisme quitte les faces que l'on met en contact pour réfugier sur les parties extérieures. En même temps, les deux courbes se rapprochent l'une de l'autre et du milieu de l'aimant. Cet effet augmente avec une troisième lame et avec une quatriéme. Finalement les deux courbes se joignent en milieu."

In applying the formula to this case of a compound magnet, we have only to remark that when the bars lie closely together, they are theoretically the same as a solid magnet of the same section, but are practically found to be stronger, because thin bars can be tempered more uniformly hard than thick ones. The addition of the bars to each other is similar to an increase in the area of the rod, and should produce nearly the same effect on a rod of rectangular section as the increase of diameter in a rod of circular section. Now the quantity $p=\frac{rd}{2}$ is nearly constant in these rods for the same quality of steel, whence r decreases as d increases; and this in equation (17) shows that as the diameter is increased, the length being constant, the curves become less and less steep until they finally become straight lines. This is exactly the meaning of M. Jamin's remark.

Where the ratio of the diameter to the length is small, the curves of distribution are *apparently* separated from each other, and are given by the equation

$$\lambda=\frac{\mathfrak{H}}{4\pi\sqrt{\mathrm{R}\mathrm{R}'}}\varepsilon^{-rz}, \quad . \quad . \quad . \quad . \quad (18)$$

which is not dependent on the length of the rod. This is exactly the result found by Coulomb (Biot's Physique, vol. iii, pp. 74, 75.) M. Jamin has also remarked this. As he increases the number of plates, he states that the curves approach each other and finally unite; this he calls the "normal magnet;" and he supposes it to be the magnet of greatest power in proportion to its weight. "From this moment," says he, "the combination is at its maximum." The normal magnet as thus defined is very indefinite, as M. Jamin himself admits.

By our equations we can find the condition for a maximum, and can give the greatest values to the following, supposing the weight of the bar to be a fixed quantity in the first three.

1st. The magnetic moment.

2d. The attractive force at the end.

3d. The total number of lines of magnetic force passing from the bar.

4th. The magnetic moment, the length being constant and the diameter variable.

Either of these may be considered as a measure of the power of the bar according to the view we take. The magnetic moment of a bar is easily found to be

$$M=\frac{\mathfrak{H}}{4\pi r^2 R'}\left\{\frac{b}{2}-\frac{1}{r}\frac{1-\varepsilon^{-rb}}{1+\varepsilon^{-rb}}\right\}; \quad . \quad . \quad (19)$$

and if γ is the weight of a unit of volume of the steel and W is the weight of the magnet, we have finally

$$M=\frac{\mathfrak{H}}{4\pi R' C^2}\left\{\frac{1}{2}-\frac{1}{Cb^{\frac{3}{2}}}\frac{\varepsilon^{Cb^{\frac{3}{2}}}-1}{\varepsilon^{Cb^{\frac{3}{2}}}+1}\right\}, \quad . \quad (20)$$

where $C=\frac{r}{\sqrt{b}}=p\sqrt{\frac{\pi\gamma}{W}}$.

This only attains a maximum when $\frac{b}{d}=\infty$, or the rod is infinitely long compared with its diameter.

The second case is rather indefinite, seeing that it will depend upon whether the body attracted is large or small. When it is small, we require to make the surface-density a maximum, the weight being constant. We find

$$\delta_0=\frac{\mathfrak{H}}{\gamma\pi^2 R' p}\frac{\varepsilon^{Cb^{\frac{3}{2}}}-1}{\varepsilon^{Cb^{\frac{3}{2}}}+1}, \quad . \quad . \quad . \quad (21)$$

which attains a maximum as before when $\frac{b}{d}=\infty$. When the attracted body is large, the attraction will depend more nearly upon the linear density

$$\lambda_0=\frac{\mathfrak{H}}{4C\pi R'\sqrt{b}}\frac{\varepsilon^{Cb^{\frac{3}{2}}}-1}{\varepsilon^{Cb^{\frac{3}{2}}}+1}, \quad . \quad . \quad . \quad (22)$$

which is a maximum when $\frac{b}{d}=\frac{1\,42}{p}$.

For the third case we have the value of Q″ at the center of the bar from equation (6),

$$Q''=\frac{\mathfrak{H}}{2C^2 R' b}\frac{(\varepsilon^{\frac{1}{2}Cb^{\frac{3}{2}}}-1)^2}{\varepsilon^{Cb^{\frac{3}{2}}}+1}. \quad . \quad . \quad . \quad (23)$$

The condition for a maximum gives in this case

$$\frac{b}{d}=\frac{1{\cdot}65}{p}.$$

For the last case in which the magnetic moment for a given length is to be made a maximum, we find

$$\frac{b}{d}=\frac{{\cdot}1}{p}.$$

This last result is useful in preparing magnets for determining the intensity of the earth's magnetism, and shows that the magnets should be made short, thick, and hard for the best effect.*

But for all ordinary purposes the results for the second and third cases seem most important, and lead to nearly the same result; and taking the mean we find for the maximum magnet

$$\frac{b}{d}=\frac{1{\cdot}5}{p} \quad . \quad . \quad . \quad . \quad (24)$$

We see from all our results that the ratio of the length of a magnet to its diameter should vary inversely as the constant p. This constant increases with the hardness of the steel, and hence the harder the steel the shorter we can make our magnets. It would seem from this that the temper of a steel magnet should not be drawn at all, but the hardest steel used, or at least that in which p was greatest. The only disadvantage in using very hard steel seems to be the difficulty in imparting the magnetism at first, and this may have led to the practice of drawing the temper; but now when we have such powerful electromagnets, it seems as if magnets might be made shorter, thicker and harder, than is the custom. With the relative dimensions of magnets now used, however, hardening might be of little value.

We can also see from all these facts, that if we make a compound magnet of hardened steel plates there will be an advantage in placing more of them together, thus making a thicker magnet than when they are softer. We also observe that as we pile them up the distribution changes in just the way indicated by M. Jamin, the curve becoming less and less steep.

Substituting in the formula the value of p which we have found for Stub's steel not hardened, but still so hard as to rapidly dull a file, we find the best ratio of length to diameter to be 33·8, and for the same steel hardened about 17, though this last is only a rough approximation. This gives what M. Jamin has called the normal magnet. The ratio should be less for a U-magnet than for a straight one.

For all magnets of the same kind of steel in which the ratio of length to diameter is constant the relative distribution is the same; and this is not only true for our approximate formula, but would be found so for the exact one.

Thus for the "normal magnet" the distribution becomes

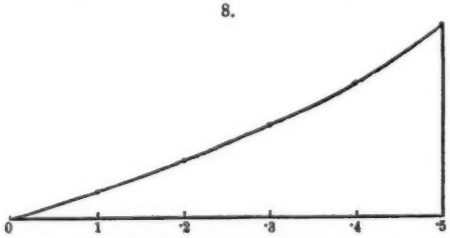
$$\lambda=C(\varepsilon^{3\frac{x}{b}}-\varepsilon^{-3\frac{x}{b}}),$$

where C is a constant, and x is measured from the center. The distribution will then be as follows:

* Weber recommends square bars eight times as long as they are broad, and tempered very hard. (Taylor's Scientific Memoirs, vol. ii, p. 86.)

$\frac{x}{b}=$	0	·1	·2	·3	·4	·5
$\frac{\lambda}{C}=$	0	·609	1·27	2·05	3·02	4·26

8.



Distribution on "normal magnet."

This distribution is not the same as that given by M. Jamin; but as his method is so defective, and his "normal magnet" so indefinite, the agreement is sufficiently near.

The surface-density at any point of a magnet is

$$\delta=\frac{\mathfrak{H}}{8\pi^2 p\mathrm{R}'}\frac{\varepsilon^{2F\frac{x}{d}}-\varepsilon^{-2F\frac{x}{d}}}{\varepsilon^{F\frac{b}{d}}-\varepsilon^{-F\frac{b}{d}}}, \quad . \quad . \quad . \quad (25)$$

which, for the same kind of steel, is dependent only on $\frac{x}{d}$ and $\frac{b}{d}$. Hence in two similar magnets the surface-density is the same at similar points, the linear density is proportional to the linear dimensions, the surface integral of magnetic induction over half the magnet or across the section is proportional to the surface dimensions of the magnets, and the magnetic moments to the volumes of the magnets. The forces at similar points with regard to the two magnets will then be the same. All these remarks apply to soft iron under induction providing the inducing force is the same, and hence include Sir William Thomson's well-known law with regard to similar electromagnets; and *they are accurately true notwithstanding the approximate nature of the formula from which they have here been deduced.*

Our theory gives us the means of determining what effect the boring of a hole through the center of a magnet would have. In this case R′ is not much affected, but R is increased. Where the magnet is used merely to affect a compass-needle, we should then see that the hole through the center has little effect where the magnet is short and thick; but where *it is long, the attraction on the compass-needle is much diminished.* Where the magnet is of the U-form, and is to be used for sustaining weights, the *practice is detrimental, and the sustaining-power is diminished*

in the same proportion as the sectional area of the magnet. The only case that I know of where the hole through the center is an advantage, is that of the deflecting magnets for determining the intensity of the earth's magnetism, which may be thus made lighter without much diminishing their magnetic moment.

In conclusion, let me express my regret at the imperfection of the theory given in this paper; for although the equations are more general than any yet given, yet still they rest upon two quite incorrect hypotheses; and so, although we have found these formulas of great use in pursuing our studies on magnetic distribution, yet much remains to be done. A nearer approximation to the true distribution could readily be obtained, but the results would, without doubt, be very complicated and would not repay us for the trouble.

In this paper, as well as in all the others which I have published on magnetic subjects, my object has been not only to bring forth new results, but also to illustrate Faraday's method of lines of magnetic force and to show how readily calculations may be made on this system. For this reason many points have been developed at greater length than would otherwise be desirable.

ART. IX.—*On rifts of Ice in the rocks near the summit of Mt. McClellan, Colorado, and on the different Limits of Vegetation on adjoining summits in the Territory;* by EDWARD L. BERTHOUD.

THE silver mines of Argentine District, a mining center about eight miles southwest from Georgetown, are located on the north slope of a high peak named McClellan Mountain, which forms a very prominent point of the main central range, and immediately facing a precipice fully 1500 feet high, the majestic mass of Gray's Peak; while 1½ miles south is Argentine Pass, 13,100 feet in height.

This mountain, 13,430 feet* above the sea, is intersected in a northeast and southwest direction by a system of mineral veins, containing silver in large quantity with a little gold. The veins seem generally to be nearly vertical, and occur at elevations varying from 12,300 feet to 13,400 feet. Three of them have been extensively mined, and two, the International and Belmont, have been developed and worked since 1867–68 with success, and with fair paying results; but with probably at a greater average cost per ton of mineral mined than any other similar mines in Northern Colorado. The Centennial Lode, the third mine examined, is now being well developed by its owners, who

* Vide Gardner, in Hayden's Report, 1873–74.

are working into the vein horizontally by excavating a drift. The ores found in these mines are galena rich in silver, decomposed quartz and honey-combed quartz, with sulphurets of silver, and some decomposed iron pyrites and a little carbonate of lead, with occasional small patches of sphalenite.

I have been thus particular in the description of these mines, merely to give a good general idea of their value and location. In a personal and critical examination of them, during a recent visit to the region, a peculiar feature was observed which excited much surprise.

The discovery-drift of the Centennial Lode runs into McClellan Mountain at an altitude above 13,100 feet, on a course southwest, at about 30 feet from the entrance of the tunnel. Intercalated in the vein, I found three or four well defined veins of solid ice, parallel with the bedding of the rock, and filling all its thinner side cracks and fissures; in fact, after further examination I found that the frozen stratum, and the congealed, hard earth, rock and gravel, began only a few feet below the accumulated rock and debris of the mountain slope, and continued as far as the excavation reached, some forty feet in depth.

From the Centennial Lode I went westward about 300 feet, and examined the drift that has been excavated into the mountain some 500 feet, upon the vein of the International Lode. Here there is repeated the same frozen substratum and the same rift or veins of ice in the country rock and in the vein. I went into the tunnel about 100 feet and found this glacial condition still existed; and the owner of the mine assured me that the ice and frozen rock continued all the way to the end of the tunnel and caused a good deal of extra expense in mining the ore.

The course of the "International Lode" is southwest, and its drift is about 50 feet in vertical elevation above the drift of the Centennial Lode.

The next "Lode" examined was the Belmont Lode, west and nearly parallel to the International. This mine is exploited by a system of horizontal galleries one above the other to the summit of the mountain, at 13,400 feet elevation. In the lower galleries the same frozen icy condition prevails as at the first two veins. But the summit drift, which was at the date of my visit about 60 feet long, does not show veins of ice in the wall-rock of the veins; this is probably due not only to the greater narrowness of the summit, here scarcely 200 feet where pierced by the tunnel, but also to the influence of wind and sun upon its western seamed and riven surface, and to its more perfect drainage and exposure.

This is certainly a singular phenomenon, when we consider that across the narrow valley north of McClellan Mt., not over

three-fourths of a mile distant and upon another high peak, the limit of tree growth exceeds 12,400 feet elevation on the south slope of that peak. Here can be seen *Pinus aristata*, some of the trees two feet in diameter and thirty feet high that retain their hold, and slowly increase in size, thus maintaining themselves in respectable numbers in spite of furious gales of snow and wind, and an extreme Arctic cold.

In Miscellaneous Publications, No. 1, U. S. Geological Survey of the Territories, which was published last year, under the direction of Prof. F. V. Hayden, the line of tree growth is given by Mr. J. T. Gardner in his report, as from 11,000 feet to 11,900 feet, between latitudes 39° and 40°. We believe this to be correct, and a fair general average. In Argentine District, which comprises McClellan Mountain, we have a very notable departure from this limit of from 500 to 1400 feet in elevation, and also about 1300 feet above timber line on Gray's Peak, three to four miles southwest, as given by Mr. Gardner. At the Equator and in the Torrid zone the limit of the growth of Pines is generally placed at 12,800 feet above the sea; how is it that, in lat. 39° 33′ N., the limit of the growth of Pines has receded only 400 feet?

In McClellan Mountain and in Argentine District there are two antagonistic phenomena in immediate proximity; on one side of the valley, a mountain slope facing northeast, well grassed, totally devoid of shrubs and trees, where soil and rocky debris are underlain by a perpetual icy coat of hundreds of feet in depth, supporting on its surface a growth of plants strictly Alpine and Arctic, and abounding with Ptarmigan, *Lagopus leucurus*, and the tailless, earless marmot; and where on the 2d October, 1875, I found the following plants yet in bloom: *Sedum stenopetalum*, *Potentilla norvegica*, *P. fruticosa*, *Sibbaldia procumbens*, *Astragalus alpinus*, *Silene acaulis*, *Draba aurea*, *Phleum alpinum*, *Primula Parryi*, *Gentiana*, *Heuchera*, *Castilleia pallida*, *Ranunculus nivalis*, *Pedicularis*, *Cardamine and Crepis*, while less than half mile distant, on the opposite slope of the vale, *Pinus aristata* of large size and a profuse growth of birches, willows, grasses and Arbutus, with flowing springs and small ponds, diversify its southwestern slope.

It has been suggested* that the frozen soil and rock of some mines examined by him, northwest from McClellan Mountain, on the west slope, have been thus left ice bound since the Glacial period; and that they thus retain their former ice-bound condition, from the excessive altitude of the mines there explored.

This may be the case, but it seems doubtful. There are in Colorado many mines at altitudes very nearly as high as the highest on McClellan Mountain, yet none have been exploited to the

* R. Weiser, in this Journal, III, viii, 477, 1874.

depth of from 100 to 500 feet in solid frozen soil and ice ribs. I am inclined to believe that the glacial condition of McClellan Mountain is due to local causes. Prominent among these would be the loose nature of the soil and deep rocky debris of the mountain, and the slow percolation of water exposed to excessive evaporation that is promoted and quickened by continued gales from the north and northwest that strike against the precipitous face of the mountain range in that direction. The opposite slope, on the contrary, which shows the abnormally high timber line, faces a Pass (Argentine Pass) 13,100 feet in height, which gives a way perfectly unobstructed for south-southwest winds. These prevail frequently in winter and spring, and are invariably temperate or even warm, and thus to their influence may be due the milder and more propitious character of this locality. In Colorado Territory it has been remarked that in our mountains, even in January, a southwest wind is invariably genial and warm; in two hours I have known a southwest wind to raise the thermometer from 13° below zero to 47° above. This abrupt change, however, is disastrous to tree growth, and destroys the quaking Asp, Cedar, and even Pines in more exposed localities; while the Cherry, Box Elder and the bitter Cottonwood (*Populus angulata*) have perished in the ensuing spring in our lower valleys and on the foot-hills.

I have presented this subject in order to secure for it further elucidation and discussion. The facts are of no little interest, since they conflict with accepted views as to the limits of growth of plant, and the influence of altitude on climate.

ART. X.—*On a New Form of Lantern Galvanometer;* by FRANCIS E. NIPHER, Professor of Physics in Washington University.*

IN the September number of this Journal, Prof. Barker has described a lantern galvanometer, which appears to possess many advantages over any heretofore described, and which is evidently a valuable addition to the apparatus of the public lecturer.

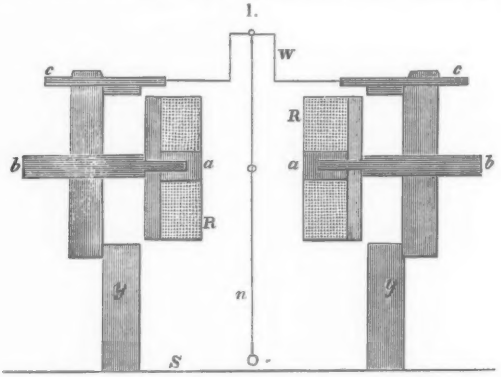
While meditating the construction of this instrument, the galvanometer now to be described was devised. A vertical section is shown in Fig. 1.

A square box (Y, Y), open at the top and bottom, is pierced on opposite sides to admit the wooden rods (*b*). To the inner extremities of these rods are attached coils (R), of covered cop-

* Read before the St. Louis Academy of Science, Oct. 18, 1875.

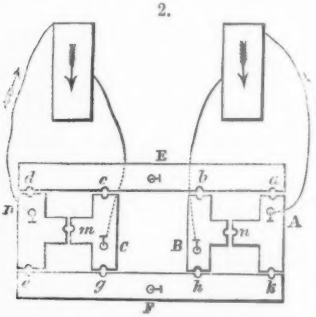
per wire, No. 14, wound upon cylinders of wood (*a*).* Wooden rods (*c*), clamped so as to move with gentle friction, bear a wire (*w*), from which an astatic system of needles is suspended by means of a silk fiber. The upper needle is midway between

1.



the centers of the two coils. The lower needle plays over a scale (*s*) photographed on glass, beneath which is the horizontal condensing lens of the vertical lantern. The needles are ordinary sewing needles, and are each 1·5 inches in length.† Each coil is composed of 34·7 meters of wire, the resistance of which is 0·444 ohms. Each coil should have the same number of windings, and the same resistance. This is easily effected by care in winding. By sliding the rods (*b*) in or out, the distance between the coils may be varied from 2 cm. to 10 cm., the image of the lower needle being in all cases perfectly distinct. In this way the instrument is adjusted to currents of any strength. Scales cut in the rods (*b*) serve to regulate the distances.

2.



On the outside of the box are six plates of brass, whose form and arrangement are shown in fig. 2. The extremities of the coils are connected with the four plates A, B, C, D. This connection may be made by means of binding-screws on the inside of the box, in which case the coils may be replaced with ease by others of greater or less resistance. The plates are put in metallic contact by means of

* For Duboscq's lantern, the coils must be placed lower than here represented.

† The lower needle may be replaced by a bristle from a painter's brush, or some other light pointer, the upper one being damped by magnets as recommended by Mayer.

brass plugs, inserted at *a*, *b*, *c*, *d*, *e*, *g*, *h*, *k*. Putting plugs at *h* and *e*, and connecting the poles of a galvanic cup at the binding-screws A and C, and the current runs successively through the two coils R, each causing deflection in the same direction. Let R represent the resistance of one coil of the galvanometer, then the resistance of the galvanometer will be 2R. This arrangement is used in working with ordinary galvanic currents.

If instead of the former connections, plugs be put at *a*, *d*, *g*, and *h*, the wires from the source of electricity being connected at E and F, then the galvanometer resistance becomes $\frac{1}{4}$R. This arrangement is to be used with circuits of small resistance, such as thermo-currents. For this kind of work the instrument is thoroughly adapted.

This instrument can also be used as a differential galvanometer. To do this, put the positive pole of the battery at E. Plug *a* and *c*. Divide the negative wire into two equal branches which are to be connected at B and D. The circuit being thus closed, the needle evidently remains at zero. Introducing any wire the resistance of which is to be determined, into one branch, bring the needle to zero again by introducing known resistances into the other, and the unknown resistance is readily determined. In measuring fractions of an ohm, a rheochord is, all things considered, the best. The contacts are good, and an audience obtains a better idea of what is meant by electrical resistance than when a resistance box alone is used. Using platinum wire weighing 7·37 grams per meter, the resistance of which is one ohm to 192·9 cm. of wire (which is 96·45 cm. on the instrument scale), and thousandths of an ohm can be measured direct.

If ground connections are made the negative pole of the battery is sent to ground direct, and the branches of the current from B and D are sent to ground through the unknown resistance and the resistance box respectively.

Shunts may be introduced into either of the half circuits. This may be done by introducing coils of resistance $\frac{1}{8}$R or $\frac{1}{99}$R, between the binding screws A, B or C, D. These wires may also be wound upon metallic plugs, which have been split lengthwise, the parts being insulated and each being connected with one extremity of the wire. Permanent shunts may be introduced by connecting one extremity with plates A or D, the other extremity being attached to an insulated plate, to be put in contact with B or C by means of a solid metallic plug. These shunts are used in Latimer Clark's differential galvanometer, and their use in measuring resistance is too well known to need further explanation.

The advantages possessed by this galvanometer are:

1. It is easily adjusted to any vertical lantern, from which it can be removed in a moment if desired.
2. The distance between the deflecting coils being readily varied, it can be adjusted to currents of various intensity.
3 The resistance of the galvanometer is quickly varied from one-half, to twice the resistance of one of the galvanometer coils.
4. The coils may be replaced by others when desired.
5. It can instantly be converted into a differential galvanometer and used in measuring resistance.
6. It can be constructed in any work-shop at a very small expense.

St. Louis, Oct. 25, 1875.

ART. XI.—*On a new occurrence of Tartronic Acid, with some remarks on the Molecular Structure of Glyceric Acid;* by SAMUEL P. SADTLER.

(Read before the American Philosophical Society, September 17, 1875.)

IN the Propyl series, nine normally formed acids are possible, besides several isomeric unsymmetrically formed ones. They are:—

I. $C_3H_6O_2$

CH_3
CH_2
$CO.OH$

II. $C_3H_6O_3$

CH_3
$CH.OH$
$CO.OH$

III. $C_3H_4O_3$

CH_3
CO
$CO.OH$

IV. $C_3H_6O_3$

$CH_2.OH$
CH_2
$CO.OH$

V. $C_3H_6O_4$

$CH_2.OH$
$CH.OH$
$CO.OH$

VI. $C_3H_4O_4$

$CH_2.OH$
CO
$CO.OH$

VII. $C_3H_4O_4$

$CO.OH$
CH_2
$CO.OH$

VIII. $C_3H_4O_5$

$CO.OH$
$CH.OH$
$CO.OH$

IX. $C_3H_2O_5$

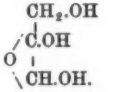
$CO.OH$
CO
$CO.OH,$

and the following are the acids considered as having the molecular structure just given:—

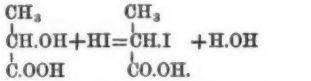
I, propionic acid; II, lactic acid (of fermentation); III, pyruvic or pyro-racemic acid; IV, ethylene lactic acid; V, glyceric acid; VI, carbacetoxylic acid; VII, malonic acid; VIII, tartronic acid; IX, mesoxalic acid.

In one or two of these cases, however, there is still a difference of opinion as to whether the acid named is the one possessing the normal molecular structure given above, or is only an isomer of it, having its carbon atoms differently united. Notably with glyceric acid is this yet an open question. Some results lately obtained in the course of a study of this acid appear to me to be of value for the solution of this question.

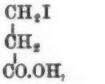
The other view of the molecular structure of glyceric acid makes it unsymmetrical, two of the carbon atoms being doubly united. The formula given is



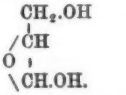
As will be seen, this formula does not contain the carboxyl group, hitherto supposed to be the inevitable characteristic of an organic acid. The author of this theory is Prof. Wislicenus, of Würzburg, and the following are the reasons given in support of it. If lactic acid be acted upon with hydrogen iodide, α iodo-propionic acid is formed, according to the following reaction:



This when heated to 150° with strong HI is changed into propionic acid. If, on the other hand, glyceric acid be acted upon with hydrogen iodide, β iodo-propionic acid is formed. If this had the formula



on treatment with moist silver oxide, it would pass into ethylene lactic acid. It does not, however, do this, but a new acid isomeric with ethylene lactic acid is formed—hydracrylic—



That the molecular structure of this acid is essentially different from that of ethylene lactic acid is proved by the oxydation products of the two. Ethylene lactic acid yields malonic acid, while hydracrylic does not yield a trace of this, breaking up into glycolic and oxalic acids and carbonic dioxide. Moreover, hydracrylic acid on heating yields acrylic acid, a derivative of allyl alcohol, instead of the lactid yielded by the lactic acids.

Prof. Wislicenus, however, frankly gives one experiment made by himself, the result of which tends the other way. He reduced the β iodo-propionic acid by sodium amalgam and obtained what appeared to be the normal propionic acid, showing the regular molecular structure.

In favor, moreover, of the normal structure for the molecule of glyceric acid is the formation of pyruvic or pyroracemic acid.

$$\begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CO.OH \end{array}$$

from glyceric acid upon heating this to 140°, explained by the following reaction:

$$\begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array} - H.OH = \begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CO.OH. \end{array}$$

The structure of this pyruvic acid is known from the fact that acted upon by nascent hydrogen it gives normal lactic acid.

A strong additional argument would be had, if we could show a connection between glyceric acid,

$$\begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array}$$

and tartronic acid,

$$\begin{array}{l} CO.OH \\ | \\ CH.OH \\ | \\ CO.OH. \end{array}$$

Hitherto tartronic acid had not been formed from glyceric acid, but only in an indirect way, by the spontaneous decomposition of nitro-tartaric acid, according to the following reaction:

$$\begin{array}{l} CO.OH \\ | \\ CH.O(NO_2) \\ | \\ CH.O(NO_2) \\ | \\ CO.OH \end{array} = \begin{array}{l} CO.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array} + N_2O_3 + CO_2.$$

However this mode of formation was interesting as tending to show its symmetry of structure. For that matter a dibasic, triatomic acid could hardly exist, except by the assumption of two carboxyl groups.

I have been fortunate enough to find tartronic acid associated with glyceric acid in the oxydation products of glycerine. The preparation of the two acids was as follows: One part by weight of glycerine is mixed with one part of water, and to the mixture is added, by means of a long funnel tube reaching to the bottom of the cylinder, about one and a quarter parts of

red fuming nitric acid. After allowing them to rest until all gas evolution has ceased (which usually takes some six days), the solution is evaporated down at a gentle heat until the fumes of nitric acid are no longer perceptible. It is then very thick and syrupy. It is now diluted with water, and plumbic carbonate is added in excess. The oxalate and undissolved carbonate are filtered off, and the solution slightly concentrated and allowed to crystallize. The glycerate of lead deposits in thick crystalline crusts. These are separated from the mother-liquor, dissolved, and the lead precipitated out from the solution by sulphuretted hydrogen.

The colorless or light straw-colored filtrate is somewhat concentrated, and calcic carbonate is added to neutralization. The solution is filtered, if necessary, and to the filtrate is added 95 per cent alcohol. The calcium salts present are all precipitated, in greater part at once, and completely on standing twelve hours.

If the solution had been very concentrated the calcium salt is precipitated in a granular condition. If, on the other hand, it was more dilute, the salt only separates gradually, and has a beautiful micaceous and scaly appearance.

I had at first considered this precipitate to be pure calcium glycerate, but found on dissolving it in water, in order to free it from the lime and obtain the glyceric acid, that while the greater portion dissolved readily in warm water, a considerable portion, although not more than one-tenth of the whole amount, remained and dissolved only on continued boiling. This, when filtered off and washed in cold water, appeared as a dull white, almost impalpable powder, contrasting in appearance with the crystalline glycerate.

It was dried carefully at 100° until constant weight was obtained.

Calcium determinations were first made. Weighed portions were ignited in a platinum crucible once or twice with excess of concentrated sulphuric acid until the weight remained constant.

·5755 grms. salt yielded ·4925 grms. $CaSO_4$, equal to 25·22 per cent Ca.

·1759 grms. salt yielded ·1505 grms. $CaSO_4$, equal to 25·16 per cent Ca.

The theoretical per cent of calcium in calcium tartronate is 25·32, while in calcium glycerate, allowing for two molecules of water of crystallization, it is 13·99.

I had analyzed the micaceous preparation of calcium glycerate about the same time, and had gotten in two determinations, 14·03, 14·07 per cent of calcium respectively. The difference was so great that I could not understand it. On

reckoning up the molecular weight, however, assuming one atom of calcium to be present, I got 159. The molecular weight of calcium tartronate is 158. Being dibasic, the molecular weight of the calcium compound is of course much less than the weight of the calcium compound of glyceric acid, a monobasic acid.

I endeavored twice to make a combustion of the salt in order to get the per cent of hydrogen and carbon. Each time calcium carbonate remained undecomposed at the heat of the combustion. I therefore gave them up.

I then took the remainder of my salt, grown rather small, to my great regret, and neutralizing the lime with oxalic acid, obtained the free acid. This, on concentration, deposited out crystals. On examination with a lens they were seen to be of tabular form, well agreeing with the appearance of tartronic acid obtained from nitro-tartaric acid. A combustion was made of these, and here, unfortunately, an accident to the potash bulbs lost me the carbon determination. The hydrogen determination, however, is given.

·4348 grms. salt yielded 13·23 grms. H_2O equal to 3·38 per cent hydrogen.

The theoretical per cent of hydrogen in $C_3H_4O_5$ is 3·33.

An important test that I wished to make but was compelled to forego for the time, was to act upon this tartronic acid with hydrogen iodide. Were its structure symmetrical, it should yield α iodo-malonic acid, which by further treatment with HI or with reducing agents would yield malonic acid.

Wishing to obtain larger quantities of the tartronic acid for further examination, I have since oxidized another portion of glycerine and treated the products in the same way. This time I got no tartronic acid whatever, at least only a trace of calcium salt remained undissolved on heating with water. Evidently here the oxidation had proceeded somewhat differently as no tartronic acid formed. This result is not surprising on reflection, as the oxidation by nitric acid is not capable of much control, and a product once formed is liable to be still further oxidized. Thus glyceric and tartronic acids are both liable to be oxidized into oxalic acid, which always forms in considerable though varying quantity. Indeed the oxidation of glycerine by nitric acid is now known to yield a variety of products, of which, however, no doubt some are secondary ones.

Thus Heintz* has proved that racemic, formic, glycolic and glyoxalic acids are all found associated with the glyceric and oxalic acids in this product.

The tartronic acid just found, therefore, is only one of sev-

* Ann. der Ch. und Ph., clii, p. 325.

eral smaller side-products. The known symmetry of structure of the molecules of all these side products, however, certainly argues in favor of a similar symmetry in the glyceric acid molecule.

There is one way of reconciling these two views of the structure of glyceric acid, and that is the assumption of the existence of two isomeric acids, of which one is normal and the other an unsymmetrical acid.

Some results that I have just obtained in purifying the calcium glycerate seem, indeed, to point this way. Should the unsymmetrical glyceric acid preponderate in this mixture, Wislicenus' reactions with hydrogen iodide are readily understood. Another fact, which should not be lost sight of, is that in the decomposition of β iodo-propionic acid by moist silver oxide, Wislicenus* obtained not hydracrylic acid alone, but three other products accompanying it, so that the decomposition was not so simple

I am now engaged upon a study of this question, and hope to be able to give more information upon it in a short time.

ART. XII.—*Note on the "Chloritic formation" on the western border of the New Haven Region;* by JAMES D. DANA.

THE rocks of the hilly region west of the New Haven plain are, for nine miles westward, metamorphic slates, and beyond this distance mostly gneiss. Immediately adjoining the region there is what Percival has called a "chloritic formation," the area trending about north-northeast; then on the west of this, with the same trend, (2) a hydromica slate, but little removed from argillite, becoming slightly garnetiferous toward the western limit; next (3) a glossy garnetiferous mica slate, containing some beds of gray semi-crystalline limestone; next (4) at Derby, common gneiss and coarse porphyritic gneiss. These rocks are involved in one system of folds, and are throughout conformable in bedding.

The rock of the "chloritic formation" varies much in texture and composition in passing from the Sound northward. Near Savin Rock, on the Sound, it is a chloritic hydromica slate. The gray and slightly silvery surface is more or less blotched and lined with the olive-green of chlorite, and the rock has in the mass in general a greenish tint. The slaty structure is usually perfect, and yet some layers fail of it. Grains of magnetite are common, and, less so, those of pyrite.

* Ann. der Ch. und Ph., clxvii, p. 41.

This slaty variety of the rock continues with little change for a mile and a half north. Beyond, the massive layers increase in extent. At the deep Derby railroad cut, two miles north of Savin Rock, the massive variety constitutes more than half of the rock exposed in the sections; and it is not all in separate beds; for thick beds that are slaty in one part are in others for many rods massive, and it is impossible to separate the massive from the slaty by any stratigraphical planes.

This massive rock is commonly without a trace of bedding; at the same time, it is variously and extensively jointed, so that it affords only deceptive indications of strike or dip. It varies in color from greenish gray to dark olive-green and blackish gray. Some of it is almost cryptocrystalline; but in general the texture is fine granular. Part of it is porphyritic with small crystals of a whitish feldspar.

Between this Derby cut and "Maltby Park," a mile and three quarters west of north, this massive rock constitutes nearly all the outcrops; and in some places the porphyritic variety is pale greenish gray, from the thickly crowded feldspar crystals.

Over Maltby Park the rock is again slaty and silvery, often with blotches of chlorite—a chloritic hydromica slate—as at Savin Rock; yet with enough of both the ordinary and porphyritic *massive* kinds among the slaty layers to exhibit its close relation to the rocks farther south. The slate occasionally has the chlorite in large lenticular concretions, and now and then is light gray and contains crystals of pyroxene. In some places, especially along seams, it is epidotic. Veins and seams of quartz are numerous. In the slate there are interrupted beds of limestone. Part of the limestone contains serpentine and is a handsome verd-antique marble; and with the serpentine there are often grayish green cleavable pyroxene (sahlite), asbestus and chromic iron.

A mile farther north, or five miles from Savin Rock, (west of Westville), the rock is almost wholly a dark green chlorite slate—the micaceous part absent.

The rocks in the course of the five to six miles are—in recapitulation—commencing at the Sound:

For 1½ miles, chloritic hydromica slate, little of it massive.
1½ to 2¼ miles, chloritic hydromica slate, much of it massive.
2¼ to 4 miles, massive chloritic rock with little of it slaty.
4 to 4¾ miles, chloritic hydromica slate, very little of the rock massive.
4¾ to 6 miles, mostly dark green chlorite slate.

It is to be noted that throughout the formation the slaty and massive portions are so associated, sometimes as alternating

beds, sometimes as parts of the same beds, that *their common metamorphic origin* cannot be questioned—a point that I have studied for years.

The resemblances of the massive rock to trap was long since noticed by Professor Silliman, who, in a paper on the geology of New Haven and its vicinity, published in 1811 in Bruce's Mineralogical Journal, called it "primitive greenstone." In fact, the similarity in external aspect is so close that hand specimens from some portions of it would without question be pronounced trap—that is, doleryte, diabase, or melaphyre—by the most experienced lithologists.

In 1872, an incomplete analysis of the feldspar in the pale grayish green porphyritic rock, outcropping just south of Maltby Park, was made, by Mr. Edward S. Dana. The amount of silica afforded by the feldspar having been found to be but 45 per cent, the conclusion suggested was that the rock consisted largely of labradorite, and that it was probably essentially identical with part of the trap of the Connecticut valley dikes. In view of the presence of chlorite, I hence regarded the compact rock of the region as a metamorphic diabase; and it is the rock specially referred to under that name in the last edition of my Manual of Geology.

Still, the analysis, besides being incomplete, was not satisfactory because the feldspar crystals, although of the normal hardness, were granular in texture, without good cleavage, suggesting that they might possibly have undergone a partial alteration. On account of Mr. Dana's departure for Europe, he was compelled to leave the investigation he had begun unfinished; and so it has remained until this summer, when it was taken up, at my request, by the skillful analyst connected with the mineralogical department of the Sheffield Scientific School of Yale College, Mr. George W. Hawes. His results prove that the rocks are in fact *metamorphic doleryte*, *metamorphic diabase*, and *metamorphic melaphyre;* the first two, labradorite rocks, and the last an oligoclase variety. To distinguish these metamorphic rocks from the igneous of the same composition, they are named, on my suggestion, *metadoleryte*, *metadiabase*, and *metamelaphyre*. The examples are part of a long series of rock species which have representatives both among igneous (or intrusive) and metamorphic rocks. Other kinds are *dioryte* and *metadioryte*, *syenyte* and *metasyenyte*, *felsyte* and *metafelsyte*, etc.

We have here the important geological fact that labradorite is a prominent constituent of certain metamorphic rocks which have the aspect of much dioryte, and which are probably of Lower Silurian origin.* The labradorite—a lime-and-soda feld-

* On the question of their age I have collected many facts and propose before long to publish.

spar—must have been a result of the metamorphic process. And its formation was probably favored by two conditions in the original mud-beds so changed; (1) the presence of a comparatively small percentage of silica, or not over 50 per cent; and (2) the presence of much disseminated carbonate of lime probably derived mainly from pulverized fossils. The fact that the chloritic formation contains two or more beds of limestone is reason for supposing that the mud elsewhere may have been more or less calcareous. The oligoclase of the metamelaphyre required for its formation only that the mud should contain a little more silica and soda and less lime.

The terms *doleryte* and *diabase* are here retained for the *igneous* rocks which have been so called—*diabase* being applied to the chloritic variety of doleryte.* Some German works on Lithology restrict the term doleryte to dolerytes not older than the Tertiary, and call the other kinds, whether chloritic or not, diabase. But this is giving different names to the same compound; and it is making geological age—a criterion fortunately never considered in the naming of other rocks—override difference of mineral composition.

ART. XIII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXVII.—*The Rocks of the "Chloritic formation" on the Western Border of the New Haven region;* by GEORGE W. HAWES.

THE rocks which compose the ridge fronting the New Haven plain on the west, in the town of Woodbridge and Orange, and which have been described in the foregoing article by Professor Dana, bear, as he states, a close resemblance to the trap rocks of the Connecticut Valley. It hence becomes interesting to ascertain whether the similarity is sustained by their chemical composition and mineral constituents.

As in the case of the trap, these rocks are of different kinds. *First*, dark-colored crystalline rocks very similar in color, texture, fracture, and specific gravity, to the undecomposed dolerytes of this region; and *second*, rocks which are more or less green and appear to be chloritic, very closely resembling the diabase. The latter kind has its porphyritic varieties. Besides these there is a *third* kind which contains a higher percentage of silica, and has the composition of melaphyre.

I. *Metadoleryte.*—A specimen collected from an outcrop about a mile south of Maltby Park (on what was formerly Mr.

* On the origin of this chloritic condition of part of the trap of the Connecticut valley—the part distinguished here as diabase—see this Journal III, vi, 104, 1873; also Mr. G. W. Hawes, ibid., ix, 191, 1875.

Stœckel's farm) was selected for analysis. It was crystalline-granular in texture; and it would be hard to detect by the eye any difference between it and many kinds of doleryte which are found in this region. The analysis shows that in chemical composition also it is very nearly the same. An analysis of a specimen of true igneous doleryte, from the trap ridge called West Rock, in New Haven, is placed beside it for comparison.

METADOLERYTE, FROM STŒCKEL'S FARM.

	I.	II.	Mean.	Doleryte, from West Rock.
Silica	50·40	50·32	50·36	51·78
Alumina	14·43	14·71	14·57	14·20
Ferric oxide	2·48	2·47	2·48	3·59
Ferrous oxide	8·28	8·35	8·31	8·25
Manganous oxide	·43	.49	·46	·44
Lime	11·15	11·11	11·13	10·70
Magnesia	7·65	7·59	7·62	7·63
Soda	3·01	3·08	3·04	2·14
Potash	·43	·44	·44	·39
Titanic acid	1·65	1·74	1·70	
Chromic oxide	*tr.*	*tr.*	*tr.*	P_2O_5 ·14
Ignition	·74	·83	·78	·63
	100·65	101·13	100·89	99·89
Specific gravity			3·04	3·03

The close resemblance between the igneous and the metamorphic rock will be noticed; they differ from one another less than do the different varieties of doleryte. Moreover, observations made upon thin sections indicate that the rock is composed of pyroxene, a triclinic feldspar, and a black opaque mineral which the analysis shows to be titanic iron. The pyroxene is a dark-green variety, but clear and undecomposed. If we assume that the pyroxene of this rock is of the same composition as that of the New Haven dolerytes,* the magnesia indicates that it contains 55 per cent of this ingredient, which being subtracted along with 3 per cent of titanic iron, leaves 41 per cent of a mineral, the oxygen ratio of which is very near to 1 : 3 : 6—proof that the feldspar is labradorite. Hence, the physical appearance, the chemical composition, and the proportion between the mineral constituents all show a very close resemblance to doleryte. The name of *metadoleryte* seems therefore to be particularly appropriate for this rock.

2. *Metadiabase*.—The chloritic variety, which has been referred to, resembles diabase in appearance as closely as the preceding kind does doleryte. There are, however, wider limits of variation in texture and in the proportion between the mineral constituents than is noticed in diabase; for the rock is sometimes uniformly crystalline, and sometimes coarsely

* See this Journal, III, ix, page 187.

porphyritic. As would be supposed, there are no amygdaloidal cavities or geodes either in the mass or in microscopic sections. The analysis was made upon a specimen collected at the Derby railroad cut where there is a fine display of these rocks. The specimen was uniform in texture and of a light-green color.

METADIABASE, FROM THE DERBY RAILROAD CUT.

	I.	I.	Mean.
Silica	48·25	48·15	48·20
Alumina	14·22	14·01	14·12
Ferric oxide	1·95	2·05	2·00
Ferrous oxide	7·39	7·43	7·41
Manganous oxide	1·30	1·19	1·24
Lime	11·53	11·47	11·50
Magnesia	8·26	8·11	8·19
Soda	2·63	2·56	2·60
Potash	·24	·23	·23
Titanic acid	1·61	1·55	1·58
Water	2·11	2·29	2·20
	99·49	99·04	99·27
Specific gravity			3·02

The analysis, taken with the observations made upon thin sections, shows that the rock is a mixture of pyroxene, chlorite, labradorite, and titanic iron, which are the constituents of diabase; and hence this metamorphic rock is appropriately distinguished by the name *metadiabase*. The absence of carbonate of lime is noticeable, showing that in this case the chlorite was formed simultaneously with the pyroxene, and not at the expense of the pyroxene, as in the case of the diabase of the trap dikes of the Connecticut valley, which always contains carbonate of lime as one result of the change. This rock in places contains pyrite, which is also frequent in trap.

PORPHYRITIC METADIABASE; SOUTH OF MALTBY PARK.

	I.	II.	Mean.		Diabase of Saltonstall Ridge.
Silica	48·57	48·65	48·61		49·28
Alumina	17·78	17·85	17·81		15·92
Ferric oxide	·35	·16	·25		1·91
Ferrous oxide	8·44	8·48	8·46		10·20
Manganous oxide	·20	·20	·20		·37
Lime	11·17	11·14	11·16		7·44
Magnesia	7·78	7·74	7·76		5·99
Soda	2·73	2·82	2·77		3·40
Potash	·47	·47	·47		·72
Titanic acid	1·35	1·35	1·35	CO_2	1·14
Water	1·60	1·65	1·63		3·90
	100·44	100·51	100·47		100·27
Specific gravity			3·01		2·86

There are varieties of this rock intermediate between these two, some specimens of which are beautifully porphyritic. In some kinds the feldspar is free from impurities; but in those varieties which are very feldspathic, and the feldspar crystals largest, these crystals are quite impure from the envelopment of chlorite. The porphyritic rock, from an outcrop near the Orange road, just south of Maltby Park, containing clear crystals of feldspar, was analyzed, and the result is given on the preceding page. An analysis of the diabase of Saltonstall Lake, from my former paper, is added for comparison.

This porphyritic rock is composed of the same minerals as the more compact varieties, for all of the ingredients can be easily recognized under the microscope. The possible presence of anorthite in the rock is suggested by the following analysis of some large grains of feldspar taken from an adjoining rock: SiO_2 45·52, Al_2O_3 29·84, MgO 2·35, CaO 15·99, NaO 1·61, KO ·37, ignition 2·38 = 98·06. This analysis was made by Mr. E. S. Dana some years since, but he states that the microscopic examination, and the analysis itself, show that the grains were very impure crystals of a triclinic feldspar, and as all the calculations upon the analyses point to the presence of labradorite, we cannot assume that any of the rocks which have been analyzed contain anorthite, though it is very likely to exist in the rocks of the series, since a constant composition in the feldspar could not be expected in the different layers of a rock made up of shifting sediments.

3. *Metamelaphyre*—a specimen taken from an outcrop on Stœckel's farm is so fine grained as to appear nearly cryptocrystalline; it is broken into angular fragments like some of our trap rocks, and in fact resembles some compact trap so closely as to make it impossible to distinguish it by the eye alone. Its analysis afforded the following results:

METAMELAPHYRE, FROM STŒCKEL'S FARM.

	I.	II.	Mean.
Silica	55·03	55·10	55·07
Alumina	14·38	13·98	14·18
Ferric oxide	7·15	7·25	7·20
Ferrous oxide	1·85	1·99	1·92
Manganous oxide	·30	·30	·30
Lime	9·05	9·01	9·03
Magnesia	6·02	5·94	5·98
Soda	4·08	4·14	4·11
Potash	·38	·37	·37
Titanic acid	1·56	1·56	1·56
Water	·68	·75	·72
	100·48	100·39	100·44
Specific gravity			2·99

If we assume that the pyroxene of this rock has the same composition as that of No. 1, we calculate, from the magnesia that it contains, 44 per cent of this ingredient; then, deducting three per cent of titanic iron, we have left a remainder of 53 per cent, which has very exactly the ratio and composition of oligoclase. This mineral constitution appears to be justified by the microscopic examination, since no free quartz or other mineral can be detected. If we restrict the use of the term melaphyre, as it is done in some recent works on lithology, to a mixture of oligoclase and pyroxene, with some titanic iron, the rock here analyzed is melaphyre in composition as well as appearance; and being a metamorphic rock, it is *metamelaphyre.*

We thus have representatives of the larger part of the pyroxenic igneous rocks, in positions which show conclusively that they are of metamorphic origin. The fact that metamorphic action can produce rocks exactly like the igneous in external aspect and chemical constituents is of great interest in the study of rocks.

ART. XIV.—*On a new Tertiary Lake Basin;* by GEORGE B. GRINNELL *and* EDWARD S. DANA.

SEVERAL Lake Basins of Tertiary age have already been discovered in the Rocky Mountain region, and the more important of them have been carefully explored. Those of Eocene age have only been known since 1870, but the Miocene deposits of the White River have long been noted for their wonderful scenery, as well as for the number and variety of the mammalian remains found in them. Another Miocene basin is known in Oregon, and both the lake beds of this period are overlaid by deposits of Pliocene age.*

During the explorations carried on last summer under the direction of Col. Wm. Ludlow, Corps of Engineers, a series of Tertiary deposits were identified by the writers near Camp Baker, Montana. These deposits indicate the existence in this region of a Miocene lake basin, which was succeeded by another lake basin in Pliocene time. As these basins are quite distinct from those heretofore known, it is considered important to put the fact of their discovery on record.

Camp Baker is situated on Deep Creek, a stream which flows into the Missouri River above Sun River. It lies about fifty miles nearly due east of Helena. It is surrounded on all sides by mountains, of which the Big Belt Range, lying immediately to the south or southwest, is the highest and most conspicuous.

* This Journal, III, vol. ix, p. 49, Jan., 1875.

The Little Belt Mountains lie to the north, and the Crazy Woman Mountains to the southeast, though at a greater distance.

The Tertiary beds found here consist for the most part of homogeneous cream-colored clays so hard as to be with difficulty cut with a knife. The beds are horizontal and rest unconformably upon the upturned yellow and red slates below. The clays of which they are formed resemble closely those found in the Miocene beds at Scott's Bluffs near the North Platte River in Wyoming. The deposits at Camp Baker have been extensively denuded and nowhere reach any very great thickness. At a point about three miles southeast of the Post, some bluffs were noticed where the Miocene beds attained a thickness of 200 feet, and these were capped by fifty feet of Pliocene clays, both beds containing characteristic fossils. In the underlying Miocene beds were found a species of *Rhinoceros*, several species of *Oreodon* Leidy and *Eporeodon* Marsh, a canine tooth apparently of *Elotherium* Pomel, and remains of Turtles. In the Pliocene beds the principal fossils were a species apparently of *Merychyus* Leidy, remains of an equine smaller than the modern horse, and Pliocene Turtles. These fossils have not yet been carefully studied, and for this reason their relations to the remains found in the other lake basins of similar age cannot here be stated.

We saw the first exposures of these beds a few miles west of the Sulphur Springs, just after crossing a rather high ridge of trachyte through which Deep Creek flows in a narrow and picturesque cañon. This point is about six miles southeast of Camp Baker. From here the lake bed was traced continuously along Deep Creek for a distance of fifteen miles, extending quite up to the mountains on the eastern side at least. Beds of the same character, containing similar fossils, were found on White Tailed Deer Creek, a branch of Deep Creek, about seven miles to the north of Camp Baker, as well as on Camas Creek to the southwest of the Post. Traces of this deposit, containing what appear to be remains of *Rhinoceros*, were also found two miles or more south of Moss Agate Springs, and at a considerable elevation above the creek bed. With more time than we had at command they could no doubt have been traced much farther, although in many places the beds have been washed out, or have been covered by the later local drift.

These Tertiary beds were all laid down after the elevation of the mountains and the igneous eruptions. They are, as has been said, perfectly horizontal, and are often seen covering over ridges of trachyte. The line of separation between the Miocene and Pliocene beds is in some places well marked. It consists of about six feet of hard sands, interstratified with

layers of very small water-worn pebbles soldered together into a hard mass, but easily picked out with a knife. Each of these layers is about six inches in thickness. Immediately above these strata the Pliocene fossils were found. In several places fragments of trachyte were noticed in the Pliocene beds.

Near Camp Baker are a series of upturned ridges of Potsdam sandstones and limestones at a level very little above that of the Tertiary beds, and doubtless in this region the lake was divided into many arms, which bent around, and extended among, these ridges.

It is known that in the neighborhood of Fort Shaw, and near Helena, Pliocene deposits exist, and at Fort Ellis and in the valley of the Yellowstone we saw, but were unable to examine, gray sands and marls, which Dr. Hayden refers to the same age. No Miocene beds, however, have been identified at any of these localities. It seems probable that in Pliocene time at least, the Baker Lake may have extended north to the Missouri River, and perhaps up that stream to the Three Forks, thus connecting with the lake which existed near Fort Ellis. Indeed it would seem that we just touched upon the southern edge of this basin, which may have extended far to the north and west.

An interesting point in connection with these deposits, is the fact that they are at a much greater elevation than any other beds of the same age now known on the continent. The elevation of the White River and Colorado beds is about 3,000 feet, and that of the Oregon basin somewhat less, while that of the deposits near Camp Baker is over 5,000 feet.

In reference to the relations which this lake basin bears to the Oregon basin and to the White River deposits, nothing can be certainly known without a careful exploration of the whole region and a thorough study of its vertebrate remains. It is by no means impossible that the Baker Lake may have flowed into that at White River by some old river channel, but so little is known of the intervening country that no definite opinion can be pronounced on the subject.

ART. XV.—*Communications from the Laboratory of Williams College.* No. IV.—*On the Product of the action of Potassium on Ethyl Succinate;* by IRA REMSEN.

IN a notice published a short time ago in this Journal,* I described a few preliminary experiments, undertaken with the object of discovering the structure of a peculiar substance which is produced when potassium is allowed to act upon ethyl succinate. Since the time of the first publication, I have been engaged in prosecuting this investigation, the results of which are herewith communicated. The communication is hastened by the fact that quite recently a similar investigation has been undertaken in the laboratory of Wislicenus,† and in the publication of the experiments no reference is made to my work.

1. *Preparation and Properties.*

The substance under consideration was first obtained by v. Fehling‡ in the course of an exhaustive examination of the compounds of succinic acid. I give his description of the method of obtaining the substance: "If ethyl succinate, which has been thoroughly dried by means of calcic chloride, is brought in contact with potassium or sodium, the metal becomes oxidized, and the ether is decomposed. At the ordinary temperature the decomposition takes place more readily with potassium than with sodium. The action begins instantaneously; an inflammable gas is evolved which conducts itself like hydrogen. By gently heating the action is hastened; the mass becomes heated spontaneously, and care must hence be taken not to heat higher than 30–40° at first. In connection with the reaction a peculiar penetrating odor is perceived. If the action is too violent, the mass may easily be thrown out of the vessel in which it is contained."

"If sufficient potassium has been added the mass becomes thick and viscid, and the color of the mass is brown. This color appears to arise from secondary decomposition-products." —"If water is now added to the mass, and it be heated rapidly to boiling, a clear, yellow liquid is obtained, upon which an oily, yellowish layer floats; but it seems to be important not to heat for too long a time. The liquid congeals on cooling, forming a soft, pasty mass. By means of a filter the liquid is separated from a yellow crystalline mass, and the residue washed out with water."—"The yellowish residue upon the filter is purified by repeated recrystallizations from alcohol.

* Vol. ix, p. 120. † Berliner Berichte, viii, Jahrgang, 1039.
‡ Annalen der Ch. Pharm., xlix, 192.

The crystalline mass is now white with a slight tinge of yellow, possessing a beautiful satin-luster, and is very voluminous."

The analyses made agreed closely with each other and led to the formula $C_6H_8O_3$.

"The compound does not dissolve in water. Alcohol dissolves it readily, particularly with the aid of heat; cold ether dissolves it in every proportion. By heating with alkalies this product is decomposed, alcohol is given off which can easily be recognized by the odor; and a yellow solution is obtained, similar to that which was obtained at first by treating with water the mass which was produced by the action of potassium upon the ether. This solution contains potassic succinate." "The crystalline body fuses at 133° and sublimes completely at 206°. With ammonia this product forms a bright yellow body crystallizing in needles."

Since the time of the publication of the investigation of v. Fehling, this substance does not appear to have been reëxamined. Only Geuther* has indulged in some speculations in regard to its structure, though his speculations are not based upon new experiments. He proposed to double the formula of v. Fehling making it $C_{12}H_{16}O_6$, and then suggested that the compound was either disuccinic ether or diethyldisuccinic acid.

In view of the peculiar method of its formation, it seemed desirable to learn something more definite in regard to the chemical conduct of the body, and accordingly I prepared a considerable quantity of it and subjected it to examination. The statements of v. Fehling in regard to its preparation were found to be in the main correct. It is not a simple matter to tell when the reaction between the metal and the ether is at an end, as the mass becomes very thick, even while warm, and, the metal becoming covered with a layer of the fully decomposed mass is kept from further action. It is very important too, not to have an excess of the metal, for, as we shall see, the new subtance forms with potassic hydroxide, a compound which is easily soluble in water, and is also easily decomposed by the hydroxide, if the temperature is raised. I found it sufficient to recrystallize the product but once from alcohol, obtaining it thus almost pure, either in the form of laminæ with a strong luster, or of needles of considerable length. The alcoholic solution exhibits the property of fluorescence to a marked degree, but I have noticed that this property grows less marked the purer the compound becomes. The fusing point of the compound is given at 133° by v. Fehling, whereas I found it to be at 128°.

* Zeitschrift für Chemie, 1866, 5.

2. *Metallic Compounds.*

When sodium-amalgam is allowed to act upon the alcoholic solution of the compound, there is produced a voluminous red precipitate, which is very easily soluble in water. From the aqueous solution, chlorhydric acid precipitates a white substance which is insoluble in water and difficultly soluble in alcohol. This substance proved to be the original compound. The same red precipitate is produced when alcoholic solutions of the compound and potassic hydroxide are brought together, and a similar precipitate when sodic hydroxide is used instead of potassic hydroxide. The latter precipitate was first prepared for examination.

Sodium-Compound, $C_{12}H_{14}Na_2O_6+4H_2O$.

This compound was prepared by bringing together alcoholic solutions of the original body and sodic hydroxide. It is thrown down immediately, as a beautiful red precipitate. This precipitate consists of microscopic needles. It was filtered off and washed out with alcohol. In drying, the color changed from red to yellow, but it appears as though this change of color is not accompanied by a chemical change. The analyses gave the following results:

I. 0·201 grams of the substance gave 0·08 grams Na_2SO_4= 0·0259 grams Na.

II. 0·1202 grams of the substance gave 0·048 grams Na_2SO_4= 0·0155472 grams Na.

		Calculated.	Found.	
$C_{12}H_{14}O_6$	254	68·28	----	----
Na_2	46	12·37	12·89	12·93
$4H_2O$	72	19·35	----	----
	372	100·00		

According to this, the substance has the formula $C_{12}H_{14}Na_2O_6+4H_2O$. It is very easily soluble in water, and the body, $C_{12}H_{16}O_6$, is precipitated from this solution on the addition of an acid. By boiling with a little sodic hydroxide succinic acid is formed.

The corresponding potassium compound is mentioned by Wislicenus (loc. cit.) Another potassium compound of the formula $C_{12}H_{15}KO_6$ is also mentioned, the existence of which speaks clearly for the formula $C_{12}H_{16}O_6$ for the original substance, instead of the simple formula $C_6H_8O_3$.

Barium-Compound, $C_{12}H_{14}BaO_6+H_2O$.

If an alcoholic solution of the substance $C_{12}H_{16}O_6$ is added to baryta water, a beautiful rose-colored precipitate is pro-

duced, similar to that produced with sodic hydroxide. This was filtered off from the solution of baryta-water and rapidly washed out with hot water. During the process of filtration the surface of the liquid on the filter was carefully protected from the influence of the air by a perforated cover which was connected with a tube containing potassic hydroxide. After all baryta had been washed away, the residue was boiled with alcohol, and again rapidly filtered in order to remove any uncombined $C_{12}H_{16}O_6$. It was then dried and analyzed with the following results:

0·1904 grams of the substance gave 0·1085 grams $BaSO_4$= 0·065798 grams Ba.

		Calculated.	Found.
$C_{12}H_{14}O_6$	254	62·10	....
Ba	137	33·50	33·51
H_2O	18	4·40	....
	409	100·00	

The formula is therefore $C_{12}H_{14}BaO_6+H_2O$. The compound is very stable. As was seen above it can be boiled with alcohol or water without undergoing decomposition. It is, however, decomposed by acids just as the sodium-compound is, the substance $C_{12}H_{16}O_6$ being precipitated.

Calcium-Compound, $C_{12}H_{14}CaO_6+H_2O$.

If lime-water is used instead of baryta-water, a precipitate is produced, which is, however, of a beautiful lemon-yellow color. This was purified in the same manner as the barium-compound. The analysis gave the following numbers:

0·2172 grams of the substance gave 0·0937 grams $CaSO_4$=0·0275 grams Ca.

		Calculated.	Found.
$C_{12}H_{14}O_6$	254	81·41	....
Ca	40	12·82	12·67
H_2O	18	5·77	....
	312	100·00	

Magnesium-Compound.—When the body $C_{12}H_{16}O_6$ is boiled in water with magnesia, a purple compound is produced, which resembles the above described compounds in many respects. This is probably the same compound that is mentioned by Wislicenus as having been prepared in another way.

We have here then a series of peculiar metallic compounds, which are not salts in the usual acceptation of that term. The substance $C_{12}H_{16}O_6$ is not an acid; at least it does not contain the group COOH, for it is entirely unaffected by the alkaline carbonates, and, its metallic compounds are themselves

decomposed by carbon dioxide. Wislicenus proposes the formula

$$\begin{array}{l} CH_2.CO.CH.CO.O.C_2H_5 \\ | \qquad\qquad | \\ CH_2.CO.CH.CO.O.C_2H_5 \end{array}$$

for the original compound, according to which it is ethyl succinylsuccinate, a derivative of succinylsuccinic acid. The metallic compounds are explained by supposing the hydrogen atoms of the groups CH to be replaced by the metals, the hydrogen in these groups having a somewhat acid character. It seems to me that the great stability of the ether which we have above recognized speaks against this formula. Most acids, which consist of atoms grouped in the manner indicated by the above formula, are decomposed by boiling with baryta-water, whereas we have seen that this substance may be boiled with baryta-water without undergoing decomposition. It is true that we know very little concerning bibasic acids of this structure, and it is possible that what is true of the monobasic acids is only partially true of the bibasic. Be this as it may, it is certain that the experiments thus far published will not permit the positive conclusion that the above formula is the true one, and further investigations would be called for whether the formula is correct or not.

3. *Action of phosphoric Chloride upon the body* $C_{12}H_{16}O_6$.

With the hope of learning something more definite concerning the nature of the oxygen-atoms contained in the substance under examination, I next undertook the study of the action of phosphoric chloride upon it. At first I employed two molecules of the chloride to one molecule of the substance. When the two are brought together in a dry vessel, no action ensues until heat is applied. If the mass is very gently heated, the substance $C_{12}H_{16}O_6$ melts, and immediately reaction commences, and continues then without the further aid of heat, until the contents of the retort form a clear, homogeneous liquid. The reaction is accompanied by an evolution of chlorhydric acid, the amount of which, however, was such as to leave me in doubt whether this was a necessary product of the reaction, or was formed from the secondary decomposition of the phosphorus compound which distilled over. The oxichloride of phosphorus was distilled off by gentle heat, and the oil in the retort then treated with water. Decomposition soon began and there resulted a solid, insoluble product. On examination this proved to be the original substance $C_{12}H_{16}O_6$. As the amount of this product was comparatively considerable, I at once concluded that a chloride had been formed by the first reaction which by its decomposition with water yielded the

mother-substance. This conclusion proved subsequently to be erroneous, in such a way as to show that the first error in judgment was partially excusable. In a second series of experiments, I employed four molecules of the chloride to one molecule of the substance, and thus reached new results. The same phenomena accompanied the reaction, that were noticed in the case already described. The direct product was a clear, yellow oil. This was treated with a little cold water. At first the oil simply fell to the bottom of the vessel, but in a short time decomposition commenced, and gradually the oil disappeared, a solid product remaining in its stead. On being filtered off and examined, the solid product proved to be a new acid, comparatively easily soluble in water. In the filtrate there was also contained a considerable quantity of the new substance, which was extracted by shaking with ether. The new acid crystallizes out of the concentrated aqueous solution in laminæ which are colored yellow. In alcohol it is exceedingly easily soluble. It dissolves in a little potassic carbonate, and is precipitated from the solution on the addition of a few drops of chlorhydric acid.

As this product is easily soluble in water, it is plain that it escaped me in the first experiment, by remaining dissolved in the water which served for the decomposition of the chloride, a sufficient quantity of water having been employed to dissolve the whole of the product, if the conversion of the substance $C_{12}H_{16}O_8$ into the chloride had been complete. That which was really found in the first experiment was simply a part of the original substance, which had not been acted upon by the chloride of phosphorus.

If we attempt to distil the chloride for the purpose of purification the mass is completely carbonized. A few drops of a colorless liquid boiling at a high temperature pass over, but the quantity of this liquid is too small to admit of an examination. It is decomposed by water, and the product is solid. It was impossible to determine the nature of the solid, owing to the small quantity obtained. It is not probable that it was succinic acid, for, in that case, the chloride from which it was obtained would have become solid at a low temperature, whereas it remained liquid even when cooled down to 0°.

If the product of the action of phosphoric chloride on the substance $C_{12}H_{16}O_8$ is heated for some time, it gradually becomes solid, or nearly so, and then has the appearance of a translucent resin. I analyzed this compound, but the numbers obtained did not agree in different analyses. It appears, thus, that condensation and decomposition of the chloride are caused by heat.

As the most important result of these experiments with

phosphoric chloride, then, we see that, if four molecules of the chloride are caused to act upon one molecule of the substance $C_{12}H_{16}O_6$, a liquid chloride is formed which is decomposed by water yielding a new acid. I have not yet studied this new acid, and can, therefore, not state in what manner it is derived from the original substance. As it can apparently be prepared in any desirable quantity with comparatively little trouble, its examination will probably give interesting and positive results.

In addition to the results already recounted, I will mention the following:

1. *Acetyl chloride* exerts no influence upon the substance $C_{12}H_{16}O_6$. It simply dissolves it when gentle heat is applied, but, on cooling, the unchanged substance crystallizes out. This result could be anticipated with considerable certainty, as the presence of alcoholic hydroxyl in the substance was not at all probable. Still the experiment was necessary to prove the fact, no matter how probable it might appear.

2. *Ammonia* does not act upon the substance either in aqueous or alcoholic solution. v. Fehling (loc. cit.) states that with ammonia the body yielded a bright yellow compound crystallizing in needles. I endeavored in vain to obtain such a compound. I first boiled the substance with very strong aqueous ammonia; it remained unchanged. I then conducted dried ammonia gas into an alcoholic solution of the substance. The solution turned deep yellow in color, but I was unable to extract from it anything save the original substance. This indeed, sometimes crystallizes in needles—a fact which may have misled v. Fehling. By analogy we should expect the formation of a compound with ammonia corresponding to the metallic compound described above. It is possible that some change in the conditions may lead to its formation.

3. *Hydrogen* in the nascent state (from tin and chlorhydric acid) does not act upon the substance. If the group CO is present, it is difficult to see why this should not be converted into the secondary alcohol group CH.OH by the action of hydrogen.

4. A solution of *potassic permanganate*, as well as dilute *nitric acid*, oxidize the substance very slowly. The products of the oxidation I have not yet examined. In connection with the oxidation by means of potassic permanganate a peculiar phenomenon was noticed which deserves mention. I have stated that the oxidation took place slowly; the product was not an acid, so that the manganic oxide formed was precipitated; but, further, the substance oxidized was insoluble in water, so that the manganic oxide, being produced in contact with the

faces of the insoluble crystals, was deposited in even layers upon them, forming thus a complete envelope, and giving a genuine pseudomorph. I was at first deceived by this strange pseudomorph, believing it to be the product of the oxidation. It was insoluble in water, and appeared to be insoluble in alcohol. I found, however, afterward, that the alcohol dissolved the central portions of the pseudomorphs leaving the envelopes unchanged in form.

5. The substance was *heated with water* at 150° in a sealed tube. At this temperature decomposition took place, but not at a lower temperature. The products of the reaction were alcohol, and a solid, white crystalline substance which conducted itself in some respects like succinic acid. The alcohol was detected by placing the whole product in a flask and distilling with water. The distillate was tested by Lieben's reaction* for the formation of iodoform.

The experiments which have thus been described do not suffice to enable us to judge positively in regard to the structure of the substance under investigation. I have stated above the view held by Wislicenus, and also my objections to this view. It remains yet to be decided whether my objections are well founded, and this can be done only by the aid of new experiments.

No. V. *On the action of Ozone on Carbon Monoxide;* by IRA REMSEN and MASE S. SOUTHWORTH.

One of the most remarkable examples of so-called non-saturated compounds is carbon monoxide. If we accept the hypothesis of constant valence, the compound CO must possess free affinities, or, as some chemists believe, the two affinities of the carbon-atom, which are not saturated by the oxygen atom, must exercise an influence upon each other. We can not explain this case by assuming that two carbon-atoms are joined together by two affinities each, for we know that the formula of carbon monoxide is CO, and not C_2O_2 or a higher multiple, and, accepting this formula, it is plain that we cannot assume a double union of carbon atoms in the compound.

If, on the other hand, we accept the hypothesis of variable valence, believing that the valence of an element depends upon circumstances, we shall look in vain for circumstances which, in the one case, can cause the bivalence, in the other the quadrivalence, of the carbon-atom. A difference in temperature certainly does not cause the difference in valence. The atom

* Annalen der Chemie, Suppl. VII, 218.

of carbon is quadrivalent toward oxygen at the ordinary temperature and under ordinary conditions. How otherwise shall we explain the formation of carbon dioxide in the processes of decay, fermentation, etc.? But the atom of carbon is just as positively quadrivalent at high temperatures.

The comparative ease with which carbon monoxide takes up chlorine appears to prove that it possesses free affinities. But if we accept this as a proof of the existence of free affinities in carbon monoxide, we have still better grounds for believing that free affinities are present in ethylene, for this gas combines with chlorine much more readily than carbon monoxide does. Still the view is commonly held that in ethylene the two carbon-atoms of the molecule are united by the mutual action of two affinities of each atom.

These considerations show that the nature of carbon monoxide is, as yet, but very unsatisfactorily understood. The first question which suggests itself is this: How far are we justified in considering carbon monoxide as a body possessing free affinities?

If we attempt to answer this question entirely without prejudice, we see that the principal experiment which is supposed to prove the existence of free affinities in carbon monoxide is the above mentioned experiment with chlorine. Oxygen does not combine with carbon monoxide at the ordinary temperature. This is readily understood, for, in order that the carbon monoxide and oxygen may combine by direct contact of the two substances, the oxygen-molecule must first be decomposed into its constituent atoms. An interesting experiment in this connection has been described by E. Ludwig,* who shows that carbon monoxide is oxidized by chromic acid at the ordinary temperature forming carbon dioxide. In this case carbon monoxide is active enough to separate one atom of oxygen from chromic acid and to employ it for the formation of carbon dioxide.

We have occupied ourselves with an experiment similar to that described by Ludwig, and have obtained a different and unexpected result. It appeared to us to be of interest to know whether, at the ordinary temperature, ozone has the power to transform carbon monoxide into the higher oxide. According to the views which are commonly held concerning the nature of the substances experimented upon, the transformation mentioned could be predicted with a tolerable degree of certainty. Particularly is this the case, if we consider the result of Ludwig's experiment, for usually ozone gives up its extra atom of oxygen with still greater readiness than chromic acid does. There is indeed no substance in the whole field of chemistry which furnishes us with a better means for obtaining

* Annalen der Ch. u. Pharm., clxii, 47.

a free atom of oxygen than ozone. If then we bring in contact with ozone a substance, which in turn is capable of taking up an atom of oxygen without itself undergoing change; which, indeed, possesses an attraction for oxygen, we are certainly justified in expecting to see the two substances act upon each other. But the experiment gave the unexpected result that ozone does not act upon carbon monoxide.

Two very careful experiments were performed. Pure carbon monoxide free of dioxide was first collected in a gasometer. This was then conducted from one side through three cylinders containing potassic hydroxide and lime-water into a flask. From the other side a current of oxygen was conducted through potassic hydroxide and lime-water, and then through a tube, in which the oxygen was converted into ozone, into the same flask. This flask was provided with a stopper having three holes. From the third hole a tube led to a cylinder containing lime-water; and this cylinder was connected with a final cylinder containing potassic hydroxide. Let us see what purposes the different parts of the somewhat complicated apparatus served. In the first place, the carbon monoxide was caused to pass through potassic hydroxide and lime-water in order to absorb every trace of carbon dioxide which might be present. The oxygen was treated similarly for a similar purpose. The ozone generator employed was that described by Wright* for use with the Holtz electrical machine, the best conditions being retained throughout the experiment for the working of the apparatus. The pure carbon monoxide and the ozonized oxygen were then caused to meet in the final flask, the inside of which was moist, as, for some unknown reason, ozone does not exhibit its oxidizing properties as well when dry as when moist. The mixture of the two gases, and any carbon dioxide which might have been formed, were then passed together into lime-water, contained in a cylinder, the lime-water being protected from the influence of the carbon dioxide of the air by the potassic hydroxide contained in the last cylinder.

Slow currents of carbon monoxide and oxygen were now passed through the apparatus, and, although the action was continued for a long time, not a trace of a precipitate could be detected in the last cylinder, containing lime-water. The strength of the gas-currents was frequently changed, but nothing brought about the expected result.

In view of the importance of the experiment we were not satisfied with this one form of it. As direct sun-light greatly facilitates the combination of carbon monoxide with chlorine, it seemed probable that it would be of service in causing the combination of the two gases under examination; and, accord-

* This Journal, vol. iv, July, 1872.

ingly, we repeated the described experiment with the following modifications: The final flask, above mentioned, in which the carbon monoxide and the ozone were brought together, was replaced by two large glass balloons, and these were placed in the direct light of the sun. Again slow currents of carbon monoxide and ozone were passed through the apparatus for hours, the rapidity of the currents being varied at different times.

In this case also we obtained only a negative result. We hence are in a position to assert positively that carbon monoxide is not oxidized by ozone.

If we now bear in mind that ozone acts destructively upon a great many saturated stable compounds, that one of the atoms of the ozone molecule has a great tendency to unite with other bodies, then the result of the above described experiments remains inexplicable. It shows at all events that carbon-monoxide itself, at the ordinary temperature, has no very great tendency to unite with oxygen, for, if our ideas in regard to the nature of ozone are correct, the conditions for such union were very favorable in our experiment.

We hope gradually to be able to experiment more fully upon this interesting subject with the object of collecting material which may enable us better to understand the nature of the so-called non-saturated compounds. We propose next to study the action of hydrogen peroxide upon carbon monoxide.

December, 1875.

ART. XVI.—*Mineralogical Notes*; by EDWARD S. DANA.—No. I. *On the Optical Character of the Chondrodite of the Tilly Foster Mine, Brewster, New York.*

IN a memoir on the Brewster chondrodite, published in the third volume of the Transactions of the Connecticut Academy, I have given the results of an optical examination of chondrodite crystals of the *second* type.* It was there shown that the optic axes lie *not* in the basal plane, but in a plane making an angle of about 154° 10′ with the base; and, in consequence, that the crystals of this type, at least from that locality, belong optically not to the orthorhombic system, but to the *monoclinic*, while the various measurements proved that the deviation in angle from the orthorhombic type could not be greater than 2 or 3 minutes. A recent repetition of the measurements with the stauroscope on the same crystals, and also on another not examined before, confirm the results ob-

* See also this Journal, III, ix, 63, for extracts from the paper.

tained, and leave no room for doubt on the subject. The following is the evidence on this point thus far obtained.

Measurements on four independent crystals gave for the supplement angle made by the plane of the axes:

I.	With $e^1(\frac{2}{3}\text{-}\dot{i}=203)$, 18° 9′;	hence with basal plane,				25° 50′.
	With $e^2(2\text{-}\dot{i}=201)$, 45° 9′;	"	"	"	"	25° 46′.
II.	With $e^{\alpha}(\frac{2}{5}\text{-}\dot{i}=205)$, 40° 55′;	"	"	"	"	25° 59′.
III.	With B $(\dot{i}\text{-}\dot{i}=100)$, 65°–70°;	"	"	"	"	20°–25°.
IV.	With the basal plane, direct measurement,					25°.

I have since made an optical examination of a crystal of the third type. One single crystal of this type allowed of a stauroscopic examination. Only a small portion of it was transparent enough for use, but the circumstances allowed of a very exact adjustment according to the method of Groth, and the probable error cannot exceed one degree. The measurement gave for the supplement angle between the base and the plane of two of the axes of elasticity $7\frac{1}{2}°$, a result which, like the corresponding one obtained for the second type, is at variance with the supposed orthorhombic character of the species. The series of measurements were made at different times with independent adjustments, but no considerable variation was found in the result, so that it may be considered as being above question. It is remarkable that the correspondence between the two types is not greater. In crystalline form the third type is between the first and second. I have to regret that no satisfactory material is at hand for the extension of these investigations to the Vesuvian humite.

It may not be out of place to state here that, through the kindness of Mr. Cosgriff, the Yale College Cabinet has recently received some exceptionally large crystals of chondrodite from the Tilly-Foster Iron Mine. The crystals were quite perfect, and four inches or more in length. Like all the large crystals they are partially altered, and have therefore little luster. They are penetrated with serpentine and brucite derived from their alteration.

ART. XVII.—*On Hermannolite, a new species of the Columbium group;* by CHARLES UPHAM SHEPARD, Sr., Mass. Professor of Natural History in Amherst College.

IN vol. l, p. 90, of this Journal (1870), I described as probably new, a Columbium mineral from Haddam, Connecticut, to which in June last* I gave the name of Hermannolite, in honor

* See Popular Guide to the Museums of Amherst College, p. 71.

of Dr. R. Hermann of Moscow, to whom chemistry has been so much indebted for the elucidation of this difficult group of minerals. By reference to my description of the mineral it will be seen that I went no further than to determine the proportions of the bases, and of the metallic acids with which they were united, without attempting to ascertain the order in which the latter were present. I thus found:

Metallic acids,	78·30
Protoxide of iron,	13·86
Protoxide of manganese,	7·72
	100·28

Desirous of learning the exact proportions of the different acids, I availed myself of an opportunity during the past summer of sending specimens to Mr. Hermann for this purpose. He has had the goodness to perform the analysis, and to communicate to me his results in the following letter.

"Your opinion that the mineral from Haddam, which you most kindly named for me, was not columbite has been fully corroborated: for it contains no hyponiobous acid (Nb^2O^3), as the columbite does; but niobous acid (NbO^2); and, in addition, hypoilmenic acid (I^2O^5), and also, a small quantity of hypotantalic acid (Ta^2O^5). The chemical formala is therefore quite different from that of the Columbite: i. e., *not* RO, Me^2O^3, but

$$2(2RO, 3NbO^2)+(RO, Me^2O^5)Il^2O^5=(\tfrac{1}{4}Ta^2O^5+\tfrac{3}{4}Il^2O^5).$$

The result of the analysis was:

		Oxygen.		Calculated.
Hypotantalic acid,	7·029	1·301	5·427	5·0
Hypoilmenic acid,	14·917	4·126		
Niobous acid,	56·154	12·290		12·0
Protoxide of iron,	12·560	2·79	4·89	5·0
Protoxide of manganese,	9·340	2·10		
	100·000			

The lower specific gravity of the mineral observed by you as well as the easy solubility in sulphuric acid of the metallic acid present, are readily explained from their small content of tantalic acid, and from the greater proportion of oxygen in the niobous acid as compared with that of the hyponiobous acid in Columbite."

Moscow, Nov. 9, 1875.

The physical characters of the mineral are given in the volume of this Journal above referred to.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Didymium absorption-spectrum and the Atomic weight of Cerium.*—Bührig has examined the methods for the preparation of pure cerium and has made an elaborate determination of its atomic weight. As the absorption spectrum of didymium is so characteristic, the author made a careful study of it, with a view to use it to prove the freedom of the cerium from this metal. The pure sulphate in a tube 22 cm. long (1·0454 grams in 50 c. c. of water) gave 11 bands. Upon dilution, it was found that in this tube $\frac{1}{71174}$ gram of the sulphate in 100 c.c. water—corresponding to $\frac{1}{17942}$ gram Di,—could be detected by its bands. In a tube 52 cm. long, $\frac{1}{271738}$ gram of sulphate, corresponding to $\frac{1}{54345}$ gram of didymium, could be thus detected. Using a Duboscq, in place of the Hoffmann spectroscope, three additional absorption lines were observed, making in all 14. The spectrum given by a crystal of sulphate 0·9 mm. thick, contained 22 lines, and was considerably different from the others. Plates of these spectra are given. The cerium was obtained pure from the mixed oxalates of the cerite earths, by igniting these without the addition of magnesia, by solution in nitric acid, and precipitation of the cerium as ceroso-ceric sulphate. This precipitate, after washing, was obtained free from didymium by Gibbs' method. The atomic weight of cerium was determined from the combustion of the oxalate and was found to be, as a mean of ten closely concordant results, to be 94·1782. The author adds some analytical data concerning the salts of cerium.—*J. pr. Ch.*, II, xii, 209, Nov., 1875. G. F. B.

2. *On the Density of Platinum, of Iridium and of their Alloys.*—Sainte-Claire Deville and Debray have prepared with great care both platinum and iridium in a state of purity and have determined the density of these metals as well as that of several of their alloys. The methods which they made use of to purify these metals are given at length in their memoir. The platinum ingots weighed from 200 to 250 grams, and gave a density of 21·5. The iridium, after breaking under the rolls, had a density of 22·42104; in the ingot, as melted, of 22·239. An alloy of 90 per cent of platinum and 10 of iridium had a density of 21·615; of platinum 85 and iridium 15, of 21·618; of 66·67 platinum and 33·33 iridium, 21·874; of platinum 5 and iridium 95, 22·384; thus increasing quite regularly.—*C. R.*, lxxxi, 829, Nov., 1875. G. F. B.

3. *New method of Chlorinating Hydrocarbons.*—In the course of experiments made to discover a solvent for the comparatively unstable molybdenum pentachloride, Aronheim observed the energy with which it transferred its chlorine, even benzol when heated with it evolving torrents of hydrochloric acid gas. Further

examination showed it to be a far more energetic chlorine carrier than iodine, since (1) it acts more readily and quickly, (2) it carries the process more uniformly from one stage to the next, and (3) it can be more readily removed from the products. If to 500 grams anhydrous benzol, 5 grams $MoCl_5$ be added, and a stream of chlorine be passed through it, heat being applied by a water-bath and a return-cooler being used, after three days the liquid solidifies on cooling to an intermixed crystal mass, consisting of nearly pure para-dichlor-benzol, which after purification is equal in weight to the benzol taken. By acting on toluol in this way, the author in conjunction with DIETRICH, has obtained several new chlorine derivatives of this hydrocarbon.—*Ber. Berl. Chem. Ges.*, viii, 1400, Nov., 1875. G. F. B.

4. *On the Effect of Mass on the Chemical action of Water.*—OSTWALD has made, in the laboratory of the Dorpat University, a research upon the action of water in mass upon chemical action. A concentrated solution of bismuth chloride in hydrochloric acid was divided into 25 equal portions. To the first, water was added till a permanent turbidity appeared, and quantities of water gradually increasing from this were added to the other portions, the last receiving enough to precipitate all the bismuth. After standing six weeks, the various liquids were separately analyzed, the chlorine, bismuth, hydrogen and water being determined. These results are given in a table. To compare them a second table is given in which the chlorine and bismuth are calculated for 100 parts of water. If from these figures a curve be constructed with those for bismuth as abscissas and chlorine as ordinates, the form of the curve for two-thirds of its length is a hyperbola. The first third is nearly a straight line, differing from this no more than is allowed by experimental errors. Hence either Berthollet's law is true and the action is exactly proportional to the mass, the curve being due to foreign influences, or the law of the action of mass is a function of a higher order, and Berthollet's law only a special case of it, where the higher powers are neglected. The author inclines to the former view; since he has detected one such disturbing cause in the fact that considerably more of the bismuthyl chloride remains suspended in the diluter than in the more concentrated liquids.—*J. pr. Ch.*, II, xii, 264, Nov., 1875. G. F. B.

5. *Formation of Alizarin by Reduction of Rufigallic Acid.*—WIDMAN has observed that when rufigallic acid is reduced by sodium amalgam, a violet solution is obtained. On precipitating this by hydrochloric acid and dissolving the precipitate in potassa, barium chloride throws down a second precipitate, which when treated with HCl leaves a residue. This dissolved in methyl alcohol or acetic acid, is left on evaporation. Heated to 250°, it sublimes in brilliant orange-red needles, having all the reactions of alizarin. Hence rufigallic acid is hexa-oxyanthraquinone $C_{14}H_2\left\{\begin{matrix}(C)''_2\\(HO)_6\end{matrix}\right.$, and the production of alizarin in the vegetable kingdom, is explained.—*Bull. Soc. Ch.*, II, xxiv, 359, Nov. 1875. G. F. B.

6. *On the Separation of Mixed Liquids.* — DUCLAUX has made a careful study of the conditions under which a homogeneous mixture of two liquids will separate into two entirely distinct layers, and has arrived at some very curious results. He finds, for instance, that a mixture of 15 cubic centimeters of amyl alcohol, 20 cubic centimeters of ordinary alcohol and 32·9 cubic centimeters of water, gives at the temperature of 20° C., a molecularly unstable grouping, so that the least diminution of temperature causes it to separate into two nearly equal layers: He states that under these conditions the composition of the two layers is invariably the same whatever the composition of the initial liquid, the layers varying only in amount. The same fact is also true of three as of two liquids; though in this case the third liquid takes no part in the separation, and remains the same in each of the two layers as in the original liquid. Hence it is always possible to start with a given liquid such that by depression of the temperature, two layers of the same volume are produced. The range of variation of temperature necessary to effect this separation is extremely minute, being much less than a tenth of one degree Centigrade! Moreover, the introduction of mere traces of certain substances, as sodium and calcium chlorides and other soluble salts, and the vapor of chloroform produce the same effect as a lowering of temperature. So also a drop of water or one of amyl alcohol will cause the separation. The author has applied this phenomenon to the construction of an ingenious minimum thermometer. By varying the amount of water present in the above mixture for example, the temperature at which separation ensues may be varied. The solutions may be readily prepared by taking the necessary quantities of amyl and ethyl alcohol, maintaining them at the exact temperature required and adding water drop by drop, until a slight turbidity appears, which should dissolve upon the slightest heating. The mixture is then placed in a tube and this is hermetically sealed. Ordinarily the liquid is clear but it becomes turbid as soon as the temperature falls below that at which it was prepared. A few drops of carmine in ammonia makes the separation more distinct, since the lower layer only is colored. If ten parts of ether be mixed with six of commercial methyl alcohol, and water be carefully added as above, a liquid will be obtained acting as a maximum thermometer, since it becomes turbid and separates when the temperature rises above that at which it was made. This is colored with a little blue ink. Several tubes of each kind would evidently be exceedingly useful in maintaining a given temperature constant for any purpose, since they could be graduated to any interval.— *C. R.*, lxxxi, 815, Nov., 1875. G. F. B.

7. *Stationary Liquid Waves.* Professor GUTHRIE has recently communicated to the London Physical Society the results of his observations on wave motion. If water in a cylindrical vessel, not less than nine inches in diameter, be agitated by depressing and elevating a flat circular-disk on its surface at the center, a form of

oscillation is set up which the author terms binodal. He finds that these fundamental undulations in an infinitely deep circular vessel are isochronous with those of a pendulum whose length is equal to the radius of the vessel, and that the pendulum and water keep together throughout their entire paths. This was shown experimentally by a short pendulum with a heavy adjustable bob, having a card-board sector attached to its upper end. A silk thread attached to the edge of this sector carries a small paraffin disk, which rests at the center of the surface of the water contained in the cylindrical vessel. The length of the pendulum is altered until the motion of the disk is isochronous with that of the water. Two other forms of motion may also be produced by alternately compressing and extending opposite diameters, as in a bell, and by rocking the vessel. Each has its own period, the last being the slowest. They may be superposed and a rotation of the water, however great, does not interfere with their formation.

In rectangular troughs binodal and mononodal waves may be formed, the former by raising and lowering a wooden lath at the middle of the surface, and the latter by tilting the vessel. Experiments of binodal motion show that they are isochronous with a pendulum whose length is 2 divided by π times that of the trough. The principal questions still to be considered are: (1) Why are the motions pendular? (2) How is it that in circular binodal motion the times are identical with that of a pendulum of given length? and (3) What is the mathematical connection between the individual motion of each particle and that of the mass?—*Nature*, xiii, 99. E. C. P.

8. *Waves in Elastic Tubes;* M. Marey has studied the laws of the circulation of the blood by a mechanical representation in which a liquid wave is made to traverse an elastic tube. The changes in the shape of the tube are measured at six points by small elastic reservoirs connected with a chronograph so that the form of the wave and its time of transit past each point, are represented graphically. The wave is generated by forcing water by a pump into the tube. Positive waves are thus formed which follow the general laws of undulatory motion. The velocity is proportional to the elasticity of the tube and inversely as the density of the liquid. It diminishes gradually as the wave progresses and increases with the rapidity with which the liquid is added. With a sudden addition of liquid, secondary waves are formed of continually diminishing amplitude. When the tube is closed or narrow at the end, reflected waves are formed. If the walls of the tube are not very extensible, harmonic vibrations are formed superposed on the primary waves. In branching tubes a very complicated combination of waves is formed passing from tube to tube. But in the case of the blood the aorta does not permit the waves to pass from one artery to another. Its own waves are transmitted to the arteries where they are gradually lost, but like an elastic reservoir it absorbs and extinguishes the reflected waves.—*Journ. de Phys.*, iv, 25. E. C. P.

9. *Transparency of Flame and of the Air.*—M. E. ALLARD has presented to the French Academy several memoirs on the absorption of the light of lighthouse lamps. The first memoir relates to the transparency of flame. From one to six concentric wicks are used in lighthouse lamps, having a diameter of from 3 to 13 cms. A comparison of the luminous intensity of the flames shows that the brightness increases a little less rapidly than the consumption of the oil; comparing the intensity with the dimensions of the flame, it appears that the brightness per square centimeter increases, but that per cubic centimeter diminishes with the size of the flame. This difference may be accounted for by assuming that the flame is not perfectly transparent. Three methods were adopted for measuring the absorption, by comparing the light of the edge and side of a flat flame, by reflecting the light a second time through the flame by a mirror, and by viewing the electric light through a large flame. The results lead to the coefficient of ·80 for the absorption per centimeter in thickness.

After having established the theoretical formulas which give the effective brightness of the flame as a function of its volume and coefficient of absorption, it appears that to satisfy the observations we must assume that the specific brightness increases a little with the diameter. Multiplying then the specific brightness by the volume, it appears that the total quantity of light increases much more rapidly than the weight of oil burned; but as the quantity of light absorbed increases still more rapidly, the light increases a little less rapidly than the oil consumed, as experiment shows.

The second memoir relates to the nocturnal transparency of the atmosphere. Observations are made three times every night by the lighthouse-keepers, as to which of the adjacent lights are visible. Combining the results for several years gives the percentage of nights on which each light is seen. The equation of the range of visibility and a graphical construction serve to show for each light in all cases what degree of transparency of the air is needed to render the light visible. A curve may then be constructed with the transparency of the air and the visibility of the lights as coördinates. From this it appears that during half the year the coefficient of transparency per kilometer exceeds ·91 in the Atlantic and ·932 in the Mediterranean. Similar curves give the transparency at different points along the coast, and during the four seasons.

The third memoir treats of the apparent brightness of a light caused by revolving the system of lenses employed with greater or less rapidity. With a certain velocity, a flickering effect is produced, but with an increased speed the light becomes steady with an intensity one or two tenths less than would be obtained by distributing the light uniformly around the horizon.—*Comptes Rendus*, lxxxi, 1096. E. C. P.

10. *Etheric Force of Edison.*—Prof. E. J. HOUSTON, in an article in the January number of the Journal of the Franklin Institute,

concludes from his experiments—as many physicists may have concluded from the published account of the supposed new force—"that all the phenomena noticed by Mr. Edison are explainable by the presence of inverse electrical currents of considerable quantity, but comparatively small intensity, instantaneously produced at the making or breaking of the battery circuit."

II. Geology and Mineralogy.

1. *U. S. Geological and Geographical Survey of the Territories*, F. V. Hayden in charge. Department of the Interior. *Bulletin No. 5, Second series.* Washington, Jan. 6, 1876.—This new Bulletin contains the following important papers: A review of the fossil flora of North America, by L. Lesquereux; New fossil plants of the Lignitic formations, and from the Dakota group of the Cretaceous, by L. Lesquereux; Notes on the Lignitic group of Eastern Colorado and Wyoming, by F. V. Hayden; Geology of localities near Cañon city, by S. G. Williams; On *Zapus Hudsonius*, and on the breeding habits, nest and eggs of *Lagopus leucurus* (the white-tailed Ptarmigan), by Dr. Elliott Coues, U. S. A.; List of Hemiptera of the region west of the Mississippi, including those collected during the explorations of 1873, by P. R. Uhler; On the supposed ancient outlet of Great Salt Lake, by A. S. Packard, Jr.

The question as to the age of the Lignitic beds is here discussed anew by Prof. Lesquereux with the presentation of some additional facts. His conclusions remain unchanged. They are as follows.—Above the Lower Cretaceous beds or those of the Dakota group, in the Rocky Mountain region, the first fossil plants met with are the species of the Lignitic formation. This formation is divided into (1) the *Lower Lignitic*, marked by the presence of a profusion of Palms, especially species of *Sabal* (showing a warm, moist climate, like that of Florida, while the Cretaceous plants of the Dakota group indicate one like the present of Ohio) along with species of *Ficus*, *Cinnamomum*, *Magnolia*, *Myrica*, *Quercus*, *Platanus*, *Diospyros*, *Mamnus*, *Viburnum*, etc. (and as yet no *Acer*), and referable to the *Eocene;* (2) the Evanston group, "considered *Upper Eocene* or *Lower Miocene;*" (3) the Carbon Group (more to the eastward, about long. 106½° W.) "or *Middle Miocene*," above which comes (4) the Green River Group, or *Upper Miocene.* The flora of No. 2 includes thus far 90 species, of which a third are known from No. 1: fruits have been found that have been referred to the Palms, but no leaves; there are also in it dentate and serrate leaves of *Salix*, *Betula*, *Alnus* and *Acer.* The flora of the Carbon Group is "positively Miocene;" 18 species, or nearly a third of all, are identical with European Miocene plants, and 13 with Arctic Miocene, while a few occur also in the Lower Lignitic (No. 1.)

Among 23 species from the Point of Rocks, referred to No. 1, or the Lower Lignitic, two occur also in beds to the north of the

United States boundary, called Tertiary by G. M. Dawson, seven are identical with, and five related to, species of the Lower Miocene of Europe, two occur in the Arctic Miocene, three are found also at Golden, eight at Black Butte, and two have some analogy with Cretaceous types.

Hayden, in his remarks on the Lignitic beds, observes that there are lignitic or coal beds in both the Cretaceous and Tertiary formations of the Rocky Mountain region; but that, so far as Eastern Colorado is concerned, from Raton Hills to Cheyenne, the lignitic beds are not associated with marine deposits, but those of brackish water or freshwater origin, and that these are not Cretaceous, but of Eocene age, the evidence from the plants pointing, according to Lesquereux, to this conclusion. He further states that in Southern and Southwestern Colorado, as shown by Mr. Holmes and Dr. Endlich of the expedition, and also other authorities, heavy beds of coal occur all through the Cretaceous. Hence, taking, he says, the whole Rocky Mountain region into view, there is a *Lower Lignitic* group which is *marine* and *Cretaceous;* above this, the *Middle Lignitic*, *brackish water* in origin, which is *Lower Tertiary* or *transitional;* and next the *Upper Lignitic*, *freshwater* in origin, which is unquestionably *Tertiary*. The coal deposits of Carbon are included in the third of these divisions, and those of Bear River and Coalville in the first. Dr. Hayden observes that Dinosaurian remains occur even in the freshwater or upper division, as noticed by Cope and Marsh; but that the species are not identical with any known Cretaceous species. The Green River beds overlie the Lignitic beds unconformably.

The difference between Prof. Lesquereux's view and those of Dr. Hayden appears to be this: Lesquereux makes the Eocene to include the Bear River and Coalville beds, and all the older Lignetic beds the fossil plants of which he has examined (including those even of Vancouver Island, where Ammonites and Baculites occur in beds *overlying* the coal); while Dr. Hayden admits that there is a series of Cretaceous coal beds, that the Bear River and Coalville deposits are included in it, and that these Cretaceous strata are distinguished by being mainly marine and containing Cretaceous fossils.

Between the views of Prof. Lesquereux and those of the zoological paleontologists the divergence is great. For while he makes the Green River beds (containing remains of fossil plants and fishes) "Upper Miocene," and the Carbon beds "Middle Miocene," Leidy, Cope, and Marsh hold that even higher strata, namely, those overlying the Green River beds conformably (having an estimated thickness of five or six thousand feet) and which contain the oldest Mammalian remains of that part of the continent, are *Eocene;* and that the underlying Green River beds are *Lower Eocene;* and further that all the Liginitic beds, that are older than the Green River beds, are *Cretaceous*, since they contain Dinosaurian remains, and some of them other Cretaceous fossils.

Thus widely the best authorities differ; partly because European tests of geological age are not always good for use in America, and partly, also, from deficient American testimony. We are disposed, with the present light, to argue the case as follows:

First. It is highly improbable that the type of Dinosaurs should have been represented all through the Eocene and into the Miocene—as must be true if Lesquereux's conclusions are right.

Secondly. Mammalian fossils are a far safer criterion of geological age than fossil plants—since the changes in the species of mammals through the successive eras of the Tertiary are vastly greater than in those of plants; and as the mammals of the beds next above the Green River beds are strongly Eocene in their characteristics—as attested to by Leidy, Marsh and Cope—it is exceedingly improbable that the beds affording the fossil mammals should be Upper Miocene, or Miocene at all.

Thirdly. If the beds containing these mammalian remains, together with the *underlying* Green River beds, are *Eocene*, then the Evanston beds, and the Carbon beds also if older than the Green River, are either earlier Eocene or Cretaceous. It follows also, *fourthly*, that the "Miocene" features of the plants of the Liginitic beds are not due to the plants being of Miocene age; and hence, *fifthly*, that the diversities in the cotemporaneous Tertiary flora of Europe and North America are so great that little use can be made of the facts from one continent for fixing the chronology of beds in the other.

It is probable, that part of the diversity in vegetation of different localities was owing to local physical conditions, and to migrations consequent on changes of climate with the progress of time during the Lignitic era; and that much of the diversity between America and Europe was due, as suggested by Lesquereux, to many of the Miocene plants of Europe having previously existed as Eocene or Cretaceous plants in America.

If the fossil plants are an uncertain test of geological age, so may it be also, to some extent, with the fossils animals, when characteristic species are sparingly present. Even the existence of Dinosaurian remains in the later Lignitic, and of Inocerami where Ammonites and Baculites are absent, may not prove absolutely that the beds containing them are Cretaceous rather than Lower Eocene, since some animals species may have survived the changes separating the two eras, as has happened in the case of other successive eras.

In the paper, *on the former outlet of Great Salt Lake*, Dr. Packard points out that General Connor has found, by his railroad surveys, that the lowest part of the including rim of hills is at Skull Valley, west of the lake, and that the height there is "somewhat over 100 feet above the present level of the lake." He adds that the river-bed has been traced southward over 100 miles to the Sevier Lake Valley, passing west of Sevier Lake. It is probable, further, that the river joined the Colorado near the confluence of the Muddy River and Rio Virgen; but it may have had an

independent outlet into the Dry-Lake Basin north of east of San Diego, a region seventy feet below the present sea-level. Dr. Packard hence concludes that the lake was once fresh, and that it has become salt by evaporation and contributions from salt springs and the soil. J. D. D.

2. *Drift formation and Gold in Missouri;* by G. C. BROADHEAD.—The drift of Missouri is confined to the part of the State north of the Missouri. The upper beds are chiefly sand with some small pebbles and a little clay; lower down are large bowlders, and at base are blue clays. In Sullivan Co., and the western part of Adair the depth is 50 to 60 feet; in Davies Co., 40 to 80 feet; in northeastern Adair, over 100 feet; in Knox, 200 feet; in Putnam, over 70. In Illinois, in Moultrie Co., the depth is over 200 feet, as shown by wells, and in Decatur Co., over 90 feet. Gold has been found in Missouri, in Chariton, Linn, Adair, Putnam, Sullivan and Mercer Counties. It is in very small grains, the largest particles, from Adair Co., are not larger than a grain of wheat.—*Mines, Metals and Arts, St. Louis, Dec.* 9.

3. *Glacial striæ north of Lake Ontario, in the Ontario district, Western Canada.*—Prof. CHAPMAN, in a paper on the Geology of Ontario (Canadian Journ., xiv, 580, Dec., 1875) states that the limestone strata beneath the glacial and post-glacial deposits (which cover a large part of the Lake Ontario district) are found to be generally striated, and that the striæ run commonly in a *southwest* direction. The direction proves that the slope of the upper surface of the glacier in that region was from the northeast to the southwest; or that the greatest height of the ice surface lay somewhere to the northeast of that district.

4. *New Fucoid from the Water-lime Group (Lower Helderberg) of Western New York.*—Messrs. A. R. GROTE and W. H. PITT have described a species of *Buthotrephis*, from the Water-lime, which they call *B. Lesquereuxi*. The stem, originally cylindrical, branches from the base; and the branches are simple or sparingly dichotomous, smooth, 13 to 14 cm. long, 3 to 4 mm. thick, but gradually widening to nearly 1 cm. at the obtuse or round-truncate point.—*Bull. Buffalo Soc. Nat. Sci.*, 1876 (January), p. 88.

5. *Petrifaction.*—CHEVREUL, in a paper before the French Academy, sustains the view that the petrifaction of an organic substance, as wood, comprises two epochs: the *first* is that of the filling of all the interstices and pores of the solid body by a solution of the mineral material through capillary action, to fix it chemically by affinity upon the solid portion—producing a petrifaction which has the figure of the interstices and pores; and the *second* includes the time of the total disappearance of the organic matter itself and its replacement by the mineral material, the result of this action having the actual form of the organic matter.

Daubrée, after the reading of M. Chevreul's paper, mentioned facts from the hot baths of Bourbonne-les-Bains confirming his conclusions. He stated that wood occurs in the waters in all states of change by the petrifying agent, carbonate of lime. In

one specimen a portion was nearly 97 per cent carbonate of lime, all the organic tissues but 3·1 p. c. having disappeared; while in another portion, less changed, only the interstices and cellules were filled by the carbonate of lime. In one specimen the wood nearest the bark and the bark contained no carbonate of lime, as was easily proved by an acid.

6. *Green Mountains.*—On page 498 of the last volume of this Journal (Supplementary December number), a note is inserted correcting the blunders which have long circulated in Geographies, Gazetteers, Encyclopedias, and New England Guide-books, as to the Green and White Mountains terminating in trap ridges—called West and East Rocks—in the vicinity of New Haven; the fact being that East Rock is but a short appendage (half a mile long) to the system of trap dikes of the Connecticut valley, and West Rock, a southern portion of the same system. Prof. O. P. Hubbard has informed the writer that this extraordinary error in New England Geography has the following forms in "The Imperial Gazetteer" published by Blackie & Son at Glasgow, Edinburgh and London, in 1855. Under NEW HAVEN, "Surrounded on three sides by spurs of the Green Mountains." Under GREEN MOUNTAINS, "A mountain range commencing near New Haven, Connecticut." Under CONNECTICUT, "Some of its mountains, particularly the Green Mountain range," etc.

The Green Mountains consist of metamorphic rocks and are not younger than Silurian. They have their greatest height in Vermont, and there received the name. The mountain system extends south through *western* Massachusetts and *western* Connecticut, and the whole is rightly called the Green Mountain chain. But the trap ridges of the Connecticut valley, belong to the valley, and are of Jurassic origin. J. D. D.

7. *Geology of New Caledonia.*—The formations of New Caledonia, below the Quarternary, according to M. Garnier, include the Lower Neocomian (Lower Cretaceous); Upper Lias (containing *Nucula Hammeri*); Lower Lias (containing *Ostrea sublamellosa*, &c.); Upper Trias (containing *Halobia Lomelli*); Lower Trias (with *Avicula Richmondiana*); Upper Devonian and Upper Silurian; besides also crystallized rocks. Among the last mentioned are mica schist and argillaceous slate with quartz veins, some of them auriferous, amphibolite, talcose slate and serpentine, with crystalline limestone. At Koé and Karigou the coal is anthracitic, partly graphitic; and at the latter place it is said to have been rendered anthracitic by a dike of euryte porphyry. To the northwest of Mont d'Or it is bituminous, but impure.

The serpentine or magnesian rocks cover a large part of the island. The serpentine contains bronzite or diallage, chromic iron, magnetite, "hydrosilicate of magnesia," and is traversed by "veins" of chrysolite. It passes into white argillaceous [probably hydro-mica] schists, and these are intimately associated with the serpentinous schists [facts which prove that the serpentine is not, as Garnier states, igneous, but, like most serpentine rocks, meta-

morphic]. Chromic iron is abundant on Mont d'Or; an analysis of it afforded

$$\dot{F}e\ 34{\cdot}00,\ \dot{C}r\ 61{\cdot}33,\ \dot{A}l\ 0{\cdot}11,\ \dot{M}g\ 0{\cdot}01,\ \dot{S}i\ 4{\cdot}63 = 100{\cdot}08.$$

Ores of nickel occur in the serpentine, and are of workable value. The only ore mentioned is a greenish pimelite-like silicate, a variety of which has been named *garnierite.*

M. Garnier, who is in charge of the New Caledonia mines under the French Government, has published on the Geology of New Caledonia in the *Bulletin of the Geological Society of France*, II, xxiv, 438, 1866, and in the *Annales des Mines*, VI, xii, 1867; and later communications have appeared in the *Moniteur de la Nouvelle Calédonie.—Abstract of part of Address of Rev. W. B. Clarke before the Royal Society of New South Wales, at the Anniversary meeting in May*, 1875.

8. *Achrematite, a new mineral;* by Prof. J. W. MALLET.—This mineral is in general compact, with indistinct crystalline structure; an examination in polarized light suggested that it might belong to either the hexagonal or tetragonal systems. Color, a sort of liver-brown, though under the microscope the pure grains appear pale sulphur-yellow. Streak, pale cinnamon-brown. Luster, between resinous and adamantine. Translucent on thin edges, in minute grains nearly transparent. G.= 5·965 on a solid fragment, but = 6·178 with a fine powder. H.= 3–4. Fracture uneven; brittle. A mean of three analyses gave, after deducting impurities,

$$\tfrac{2}{3})As^2O^5,\ 18{\cdot}25,\ MoO^3,\ 5{\cdot}01,\ Cl\ 2{\cdot}15,\ Pb\ 6{\cdot}28,\ PbO\ 68{\cdot}31 = 100{\cdot}00,$$

which makes *achrematite* a molybdo-arsenate of lead. Several reasons are given for the conclusion reached that the arsenate and molybdate of lead are in chemical combination, and not mechanically mixed. The name is derived from ἀχρήματος, in allusion to the fact that it contains no silver as was alleged. Locality, the mine of Guanaceré, State of Chihuahua, Mexico.—*J. Chem. Soc.*, II, xiii, 1141, Nov., 1875. E. S. D.

9. *Schraufite*, a new fossil resin from Bukowina described by v. Schröckeringer. It occurs in rounded masses imbedded in a bed of slatey sandstone. Its hardness is 2–2·8; specific gravity 1–1·2; fracture conchoidal; color hyacinth-red. It is decomposed with the evolution of gas at a temperature of 326° C. Its composition, according to Dietrich is $C^{11}H^{16}O^2$. It is named after Professor Schrauf of Vienna.—*Verh. G. Reichs.*, May, 1875, p. 134. E. S. D.

10. *Identity of Seebachite with Phacolite;* v. RATH.—The zeolite from Richmond, Victoria, described by Ulrich and later made identical with herschelite by von Lang, was made a new species by Bauer, under the name of seebachite (Dana's Min., Appendix II, p. 50). A recent examination of the mineral, upon some good crystals, by vom Rath, has proved that the mineral called seebachite is not orthorhombic, as claimed by von Lang, but rhombohedral, and that it is really indentical with phacolite, a variety of chabazite.—*Ber. Ak., Berlin*, 1875, 523. E. S. D.

11. *A new species of Dalmania from Port Jervis, New York.*—Dr. S. T. Barrett, of Port Jervis, has recently described a new species of Dalmania from the Lower Helderberg of that vicinity, and named it *D. dentata.* A description by him, accompanied with a plate, will appear in the next number of this Journal.

J. D. D.

III. Botany and Zoology.

1. *Naudin on the Nature of Heredity and Variability in Plants.*—Why is it the nature and essence of species to breed true, and why do species sometimes vary? In other words, why is offspring like parent, and when unlike in certain particulars, what is the cause and origin of the difference? We commonly and properly enough take these two associated yet opposed facts as first principles. But it is equally proper and legitimate to enquire after the cause of them.

M. Naudin, a good many years ago, took up the study of hybrid plants, and followed up, for a series of generations, the course of life of certain self-fertile ones, notably of *Datura.* We gave at the time an abstract of his observations of the manner in which the characters of two closely related common species, *D. Stramonium* and *D. Tatula,* were mixed, and in which the characters of the two began to separate in the close-bred progeny of the next generation, ending in a complete division of the amalgamated forms into those of the two constituent species after a few generations.

The *Comptes Rendus* of Sept. 27th and Oct. 4th, 1875, contain an abstract of a paper communicated by M. Naudin to the French Académie des Sciences, of which the text was suggested by a hybrid between the wild *Lactuca virosa* and a variety of *L. sativa,* the common Lettuce. The hybrid was an accidental one: its seeds were fully fertile; a great number of young plants were raised from them, of which twenty were preserved for full development and study. Like other hybrids the original showed no character which was not evidently derived from the two parents; and, fertilized by its own pollen, the offspring all agreed in this respect, although they varied exceedingly among themselves in the division of the parental heritage, no two being quite alike. This exceeding vacillation between the two parental forms but not overpassing the limits on either hand,—which Naudin finds to be the common characteristic of fertile hybrids, close-bred — he names disordered variation (*variation désordonnée*). His explanation is, that the hybrid is a piece of living mosaic, that two specific natures are at strife in it; in the progeny each endeavors to reclaim its own, like seeks like; whence in the course of a very few generations (as he first showed in *Datura*), a segregation takes place, part of the progeny reverting completely to one ancestral type, part to the other. What Naudin now insists upon is that out of all this disturbance comes nothing new; that there is here no variation beyond the line of inheritance; and therefore from crossing no possible development of species.

To this proposition we accede, so far as respects the direct consequence of crossing. To fill up the interval more or less between two forms or species with intermediate patterns may tend to the fusion or confusion of the two, but not to the origination of new forms or species. Although Naudin's own experiments lead him to deny all tendency to variation overpassing these limits, we do not forget that his countryman, the late M. Vilmorin,—working in a different way and with another object,—arrived at a different conclusion. He succeeded, as we understand, in originating floricultural novelties from species which refused to vary *per se*, by making a cross,—not to infuse the character of the male parent, for he fertilized the progeny with the pollen of the female parent, and thus early bred out the other blood, but to induce variation, which, once initiated in the internal disorder consequent upon the crossing, was apt to proceed, or might be led on by selection, to great lengths, according to Vilmorin. The variations in question, being mainly such as are sought in floriculture, may not have passed the line laid down by Naudin, or actually have introduced new features. But such plants would surely have no exemption from the ordinary liability to variation. If other plants vary, in the sense of producing something new, so may these.

This brings us to another inference which Naudin draws. Having observed that his hybrids in their manifold variation exhibited nothing which was not derivable from their immediate ancestry, he directly (and in our opinion too confidently) concludes that all variation is atavism,—that when real variations are set up in ordinary species, this is not an origination but a reversion, a breaking out of some old ancestral character, a particular and long deferred instance of this *variation désordonnée*, which would thus appear to be the only kind of variation. This view has been presented before, but not, perhaps, so broadly. Adducing some theoretical considerations in its favor—to which we may revert—and some sound reasons against the view that variation is caused by external influences, he declares it "infinitely more probable that variation of species properly so called is due to ancestral influences rather than to accidental actions." We might think so if these two categories were exhaustive, and external conditions must be supposed to act immediately, as the cause rather than the occasion of variation. But the supposition that "accidental actions," whatever they may be, and external influences of every sort do not produce but educe and conduct variation—which is our idea of what natural selection means—avoids the force of Naudin's arguments.

Moreover Naudin's view, regarded as an hypothesis for explaining variation, leaves the problem just where it finds it. To explain the occurrence of present and actual variations, hypothetical ones like those of a former time are assumed; the present diversity implies not only equal but the very same anterior diversity, and so on backwards. Or rather it demands a much greater diversity at the outset than now; for these aberrant forms are the rare exception, and if due to atavism they imply the loss of the many and the inci-

dental reappearance of the few. Else they would be the rule instead of the exception, and atavism would be simply heredity. This comes to the view which Mr. Agassiz strongly maintained, that really there are no varieties,—meaning, we understand, that all the forms are aboriginal, except the transient ones evidently due to circumstances.

That some variation is atavism is clear enough. This is the natural explanation of the appearance of characters wanting in the immediate parents but known in their ancestors or presumed ancestors. But the assumption of hypothetical ancestors to account for variation generally is quite another thing. Besides its inutility as an explanation, to which we have adverted, its improbability as an hypothesis is set in a strong light by Naudin's own forcible conception of the nature of heredity. What is heredity? he asks. In other words, what keeps species so true, offspring like parent, through the long line of generations? He illustrates hereditary force by comparing its action with that of physical force, in which the movement from one state of equilibrium to another is always that in which there is least resistance. From which it follows that when it has once begun to proceed in a certain course, its tendency to continue in that direction increases, because it facilitates its way as it overcomes obstacles. In other words this line becomes fixed by habit; *vires acquirit eundo;* the stream deepens its bed by flowing; and the more remote the commencement of a certain course, the more fixed its direction, and the greater its power of overcoming opposition. The species is kept true in its course by the sum of the heredities which press each individual forward in its actual direction. So that, as Naudin remarks, if we could calculate the energy with which millions of ancestors tend to impel the living representatives of the line onward in the same direction, we should better apprehend the persistence of species, and feel the great improbability that the stream will ever escape from its ancient and well-worn bed, and strike into new courses.

Now, in the first place, the more lively the conception we thus form of the invariability of species, through a happy metaphorical illustration of it, the more unlikely does it appear that early characters, long lost in the flow, should re-appear through atavism as varieties. To continue the simile, the more impetuous the stream, the less the possibility of its turning back upon itself, and resuming old characteristics. The eddies of atavism (the resumption of dropped characters) are not likely to extend back very far; and it seems gratuitous to have recourse to them in explanation of new forms. Moreover, although the stream has made its bed and lies in it, not escaping from its own valley, it is flexible enough to obstacles, is ever changing its particular course as it flows, and may by its own action send off here and there a bayou (variety) or branch into a delta of channels (derivative species).

Like Agassiz, Naudin conceives of species as originating with a large number of individuals of the same structure, and of which

numerous reciprocal crosses have determined the direction of the line in which their posterity have evolved. But he mantains that these individuals, and all existing species, had a common origin in a "proto-organism;" and that the various lines of descent acquired fixity into species only as they acquired sexuality. If we rightly apprehend it, Naudin's idea of the purport of sexual reproduction (as contrasted with that by buds) is, to give fixity to species. Our idea is a different one, both as to the essential meaning of sexuality, and as to its operation in respect to fixity. His conception may be tested by enquiring which are the more variable or sportive, seedlings or plants propagated from buds. This we suppose can be answered in only one way.

M. Naudin is a veteran and excellent investigator; and nothing which he writes is to be slighted. We have frankly set down our impressions upon a first perusal of his important communication; but are ready to revise them, if need be, upon more deliberate consideration. A. G.

2. *First Forms in Vegetation;* by the Rev. HUGH MACMILLAN, LL.D., F.R.S.E. With numerous illustrations. Second edition, corrected and enlarged. London: Macmillan & Co. 1874. pp. 438, 18mo.—The first edition under a somewhat different title, was published in 1861. In the present volume it is brought up to the time, and we suppose much amplified. As it stands it forms an excellent popular introduction, of the readable sort, to lower Cryptogamic botany, from Mosses (and even Club-mosses) to Fungi. The materials of its chapters were first used for popular lectures, and this primary form and use gives its character to this re-written and now extended volume. The author wished to recast it in a systematic mold, but was deterred not only by the labor required, but by the doubt whether it were worth the while. We fancy it is better as it stands, and more likely to fulfill its purpose, which is "to kindle the sympathy and awaken the interest of the reader in a department of nature with which few, owing to the technical phraseology of botanical works, are familiar." The book is full of information, possibly too full for the object in view, except that it cannot be amiss to gratify as well as awaken interest in the lower forms of vegetation by referring to as large a number as is practicable. The spirit in which the subject is handled is indicated by the motto: "*Deus magnus in magnis, maximus in minimis;*" and the sermonizings, being apposite, we have no right to intimate that they are too many and too long. There are good indexes of scientific and of popular names. It is not often that an amateur-botanist writes a book of this kind which is more free from serious errors or misunderstandings. But the statement that the antherozoids of mosses, although "furnished with cilia, like animalcules," yet "their motion is simply a hygrometical action, like that of the teeth which fringe the mouth of the capsule," must be one which unaccountably escaped revision, even in the edition of 1861. So also the suggestion that sexual reproduction may be gradually dispensed with in the lower plants and

animals, which is in fact corrected in the latter part of the volume. In referring to Prof. Tuckerman, we hope it may be long before he must be designated as "the *late* distinguished American lichenologist." The "conjecture" which "*may* be hazarded" that the Red Sea "acquired its denomination from the prevalence of this red alga [*Trichodesmium erythræum*] in its waters," *was* hazarded by Ehrenberg, if we mistake not, at the time of its discovery. The late Dr. M. A. Curtis, our American mycologist, informed Mr. Berkeley, as we remember, that he and his neighbors whom he instructed, procured no small supply of excellent food from the edible Fungi, which grew around his home, in the center of North Carolina, so abundantly that he opined he might have supported a regiment on them. This, we suppose, is the whole foundation for the extraordinary statement that, "During the latter part of the American war, when meat was scarce and dear, fungi, which grow in immense profusion and variety in America, formed the principal food of the Southern army." A. G.

3. *Seeds that float in water* have a certain interest in connection with questions about dissemination. Many ranked as such are fruits, botanically speaking, with spongy or cellular pericarp, or with some air-space between the pericarp and the seed itself. But there are a considerable number of true seeds with specific gravity less than that of water, some as low as 0·75. Van Tieghem (Ann. Sci. Nat., ser. 6, i, 383) finds that this is due to different causes. More commonly the seed owes its lightness to its coats, either by a separation in drying between the two, or between the inner and the kernel, leaving an air-space, or by a loose cellular structure of the coat. Sometimes, as in castor-oil seeds, the integument is heavier than water, but the kernel is so much lighter as to float the seed. This comes from a separation of the two cotyledons during the natural desiccation, leaving a considerable cavity filled with air. This is strikingly the case in the large, flat, and very dense-coated seeds of *Entada scandens*, which are well known to have been wafted across the Atlantic from the West Indies to Northern Europe and left in a condition fit for germination; while in those of *Guilandina Bonduc*, which have been known to accompany the former, the air is interposed between the embryo and the bony coat. The embryo itself, in all such cases, is heavier than water. But to this rule Van Tieghem now brings to light a few exceptions, and these in leguminous seeds. In those of *Erythrina crista-galli*, the specific gravity of the whole seed is 0·91, that of the embryo itself 0·87. Those of our *Apios tuberosa* are a little lighter, of our *Wisteria frutescens* a little heavier than this, but still lighter than water; and various common leguminous seeds, although heavier than water, are much lighter than would be supposed. This proves to be owing to a very loose and open structure of the *parenchyma* of the inner or upper side of the cotyledons (that which answers to the upper face of the leaf), leaving abundant intercellular spaces and passages, filled with air, which renders this spongy stratum light enough in certain cases to float the otherwise heavy seeds. A. G.

4. *Use of the hygrometic twisting of the tail to the carpels of Erodium.*—We have no indigenous or common *Erodium* this side of Texas; but there and in California one or two species are common. The narrow carpel is pointed at base; the long awn or style in drying bends at right angles with the carpel, and twists in many turns, depending on the amount of dryness, and untwists in a moister air or when wet. We had wondered that no one seemed to have given an account of the way in which this mechanism acts so as to bury the seed in the ground. Dispersed by the wind over the loose or sandy soil which these species prefer, the seed-bearing end being the heavier lies next to the ground, and is the comparatively fixed point, around which the long awn makes circular sweeps, whether in twisting or untwisting. This gives a rotary movement to the carpel, fixes the sharp end in the soil, and, whether twisting or untwisting, causes it to bore into and bury itself in the ground. It is the same with the grain and awn of Stipa. As to *Erodium*, we have just found that this is described by G. Roux, in the Annals of the Botanical Society of Lyons, France. He adds that, when in this way thus interred, the moisture of the soil soon destroys the epidermis and this allows the long beak to detach itself at its articulation with the style, leaving it planted in good condition quietly to germinate. M. Roux enters into details about the effect of light, heat, chloroform, etc., upon this movement, which seem to us superfluous and wide of the mark. A. G.

5. *The Lemurs not related to the Monkeys.*—In the genealogical tables of Hæckel, the Lemurs are made the point of divergence of lines leading to the Insectivores and Carnivores on one side and to the Rodents and the Monkeys on the other. MM. Grandidier and Alph. Milne Edwards, in their recent work on the Mammals of Madagascar, show that the Lemurs have striking peculiarities in the conformation of the allantois and placenta, and not the close relation to the monkeys generally supposed. By injecting the capillary vessels of the placenta and uterus they have studied the vascular relations of the fetus with the mother, and established thus profound differences between the two types, which begin even in their intro-uterine life.—*L'Institut*, Dec. 29.

6. *Fauna of the Greenland Seas.*—The Fauna of the Greenland Seas, according to results obtained by the "Valorous" (on its return from Disco), agrees with its land flora in being mainly Norwegian, there being (with the exception of the Echinoderms) an absence of many North American forms, which, as it appears, have not been found east of the meridian of Cape Chidley in Labrador. A *Campanularia* was obtained identical with one found by Mr. Eaton, of the British Transit-of-Venus Expedition, at Kerguelen's Island; also, in the towing-net, a sponge-like diatom, *Synedra Jeffreysi* Dickie, with living Globigerinæ entangled in the connecting protoplasmic matter of its frustules. The deep waters of Davis Straits afforded a mollusk which was long since found fossil in the newer Tertiary of Sicily, and was supposed to be extinct.—*Proc. Roy. Soc.*, No. 164, p. 78.

IV. Astronomy.

1. *New Planet.*—The discovery of another planet by Herr Knorre was announced by telegram to Prof. Henry, Jan. 11th.

2. *Harvard Observatory Engravings.*—The last instalments of the engravings from Harvard College Observatory have been distributed to the subscribers. Instead of 30 plates as promised, 35 have been issued. These later plates represent two star clusters, six views of nebulæ, four views of Donati's comet, and three of Coggia's comet. A letter press description of the engravings is, we understand, to be soon issued.

3. *The Uranian and Neptunian Systems investigated with the 26-inch Equatorial of the U. S. N. Observatory;* by Professor Newcomb. Appendix I of the Wash. Obs. for 1873, p. 74.—This paper is the first extended contribution of results obtained by the large Washington telescope. It is a discussion of the observations made between November, 1873, and May, 1875, upon the four satellites of Uranus, and the satellite of Neptune. It closes with tables of the motions of the satellites, for a portion of which credit is given to Prof. Holden.

Prof. Newcomb obtains $\frac{1}{22600}$ as the most probable value of the mass of Uranus, with an estimated probable error of the denominator of 100. He finds no evidence of any mutual inclination of the orbits of the four satellites and but slight evidence of any real eccentricity. The following are the mean distances from Uranus at the mean distance of Uranus from the sun: Ariel, $13''{\cdot}78$; Umbriel, $19''{\cdot}20$; Titania, $31''{\cdot}48$; and Oberon, $42''{\cdot}10$. The periods of revolution are $2^d{\cdot}520378$; $4^d{\cdot}144537$; $8^d{\cdot}705897$, and $13^d{\cdot}463269$. The former two are not changed from the determinations of Lassell and Marth. The inclination of the plane to the ecliptic is $97°{\cdot}85 - 0{\cdot}013T$, counting from the epoch 1850.

The only means of estimating the masses of the satellites is a comparison of their light with that of the planet. From this Prof. Newcomb infers that they probably do not exceed $\frac{1}{15000}$ of the planet. If so their mutual action, and the sun's action on them, are of no importance. Prof. Newcomb adds: "I think I may say, with considerable certainty, that there is no satellite within 2′ of the planet, and outside of Oberon, having one-third the brilliancy of the latter, and therefore that none of Sir William Herschel's supposed outer satellites can have any real existence. The distances of the four known satellites increase in so regular a way that it can hardly be supposed that any others exist between them. Of what may be inside of Ariel, it is impossible to speak with certainty, since, in the state of atmosphere which prevails during our winter, all the satellites would disappear at 10″ distance from the planet. The planet always presented itself of a sea-green color. No variations of tint were ever seen. Markings on the planet were not especially looked for, but had any been visible they could hardly have escaped notice."

For the mass of Neptune the value $\frac{1}{19300}$ is obtained. In the

perturbations of Uranus, Prof. Newcomb used $\frac{1}{19\,100}$. The distance of the satellite from Neptune is 16 275, its daily motion 61°·25679, its inclination to the ecliptic 145°12; and the orbit so far as observations show is circular.

No trace of a second satellite of Neptune has ever been seen, though it was several times carefully looked for under the finest atmospheric conditions.

V. Miscellaneous Scientific Intelligence.

1. *Report on the Compressive Strength, Specific Gravity, and Ratio of Absorption of Building Stones in the United States;* by Q. A. Gillmore. 38 pp. 8vo, with two plates. 1876. Official Report to the Chief of Engineers, U. S. Army. (D. Van Nostrand.)—This report contains the results of a very careful series of experiments on various building stones of the country. The method of experimenting in the crushing is particularly described, and the results as to crushing-strength with the cubes of stone in different positions, and between wood, lead and leather cushions, etc., are given in detail. The tables contain entries of 99 experiments on granites, 43 on limestones, 12 on marbles, and 62 on sandstones.

2. *Science and Art Department of the Committee of Council on Education, South Kensington.*—The Loan Exhibition of Scientific Apparatus will open on the 1st of April, 1876, and remain open until the end of September. It will consist of instruments and apparatus employed for research and other scientific purposes for teaching, and for illustration of the progress of science and its applications to the arts. Models, drawings, and photographs will be admissible where originals cannot be sent. Forms on which to enter descriptions of objects offered for exhibition may be obtained on application to the Director of the South Kensington Museum, London, S.W., and these forms should be filled up and returned as soon as possible, so that exhibitors may receive early intimation as to the admissibility of the objects they propose to send. The Science and Art Department defrays the cost of carriage, but, while using all possible care, is not responsible for loss or damage. The circular issued expresses the hope that institutions or individuals having instruments of historic interest will be good enough to lend them. The instruments and apparatus desired are of all important kinds connected with the subjects of arithmetic, geometry, measurement, kinematics, statics, dynamics, molecular physics, sound, light, heat, magnetism, electricity, astronomy, applied mechanics, chemistry, meteorology, geography, geology and mining, mineralogy, crystallography, biology, (microscopes, &c.)

3. *Works on the Paleontology of the Rocky Mountain Surveys in progress.*—The first four months of this year will witness the publication of an unusually large number of works on the invertebrate paleontology of the great Rocky Mountain and adjacent regions, some of which have been delayed several years. The following are either partly or wholly in type and will soon be published.

(1.) Paleontology of the Upper Missouri, by F. B. Meek; a quarto volume of between 500 and 600 pages of text and 45 lithographic plates of illustrations. It is confined to fossils of the Cretaceous and Tertiary periods, and is a very exhaustive treatise.

(2.) Paleontology of Clarence King's Geological survey of the 40th parallel, quarto, by F. B. Meek. This Report comprises about 150 pages of text and 17 lithographic plates. It embraces fossils of Lower Silurian, Devonian and Carboniferous ages and of the Triassic, Jurassic, Cretaceous and Tertiary periods.

(3.) Paleontology of the Report of Capt. Simpson's expedition; quarto, by F. B. Meek. Comprises about 100 pages of text and 5 lithograph plates. Cretaceous and Tertiary periods.

(4.) Paleontology of the Report of Capt. McComb's expedition; quarto. Cretaceous fossils, by F. B. Meek and Carboniferous fossils by J. S. Newberry.

(5.) Paleontology of parts of Vancouver's Island and Washington Territory, by F. B. Meek. About 100 pages octavo, and 6 plates.

(6.) Invertebrate Paleontology of Lieut. Wheeler's Explorations and Surveys west of the 100th meridian; quarto, by C. A. White. About 220 pages of text and 21 lithographic plates. This report embraces fossils of the Primordial, Canadian, Trenton, Subcarboniferous, Carboniferous, Jurassic, Cretaceous and Tertiary periods.

(7.) Preliminary Report on the Invertebrate Paleontology of the Plateau Province, by C. A. White, quarto; about 50 pages. It will embrace fossils of the Carboniferous, Jurassic, Cretaceous and Tertiary periods. Among other important facts it will contain an announcement of the existence of open-sea marine deposits at Bijou Basin, forty miles east of Denver, Colorado; the fossils of the deposit belonging to the genera *Venus*, *Mesodesma*, *Dentalium*, *Phorus* and an *Oculina* undistinguishable from the species common in the Vicksburg Tertiary beds. This is to form a part of a report nearly ready for publication by Professor J. W. Powell, Chief of the Second Division of the Geological Surveys of the Interior Department. C. A. W.

4. *Geological Map of the 40th Parallel Survey.*—Map number II, by CLARENCE KING, Geologist in Charge, and S. F. EMMONS, Assistant Geologist, has been issued as authors proofs, dated Nov. 15th, 1875.—This map, which covers the Green River Basin and most of the Uinta Mountains, a region of great geological interest, will be regarded as a model, as it has not been surpassed in accuracy and artistic execution by any similar work in this country. It is in two sheets, each 24 by 33 inches, and is on a scale of four miles to the square inch. It is the first of the series issued, and will be noticed more fully when the other parts are published.

5. *Depth of the North Pacific.*—The soundings by the "Challenger" in the North Pacific as given in the Proceedings of the Royal Society, No. 164, afford the following results:

Along a line from California to the Sandwich Islands the mean depth is 15,180 feet; and the least depth, about half way, near 13,000 feet.

Along a line from the Sandwich Islands to the Bonin Islands, south of Japan, the shoalest part is near 177° east longitude, where the depth is 6,650 feet.

Between longitude 177° E. and the Sandwich Islands the mean depth is about 16,000 feet; maximum depth, 19,140 feet; depth within eighty miles of the Sandwich Islands south of Kauai, over 14,000 feet.

Between longitude 177° E. and the Bonin Islands, the mean depth is nearly 16,900 feet; maximum, 19,720 feet.

On a line running north from the Sandwich Islands, between latitude 22° and 38° N., mean depth about 17,000 feet; and between this northern point and Japan, mean depth about 16,000 feet; maximum, 22,800 feet, within 180 miles of Japan, and minimum near 178° E., 12,300 feet.

The region of the minimum on this last route is nearly north of that on the route from the Sandwich Islands to the Bonin Islands; but the depth is greater, being 12,300 feet against 6,650 feet on the latter.

The mean depth for the north Pacific as deduced from all the deep-sea soundings is about 16,200 feet.

6. *An Iceland chain of elevations in the North Atlantic.*—The ship "Valorous," which took out stores to Disco for the British Polar Expedition, made deep-sea soundings on its return. Among the discoveries, as mentioned in a Report to the Royal Society (Proc. No. 164), was an elevation of the ocean's bottom in latitude 56° N. and longitude 34° 42′ W., to the southwest of Iceland, over which soundings of 690 fathoms were obtained between depths of 1450 fathoms on one side and 1230 on the other. Directly between this spot and Iceland, in latitude 59° 40′ N., and 29° 30′ W., H. M. S. "Bull-dog" found a similar elevation. In about the same direction, northeast of Iceland, there lies the island of Jan Mayen. This line is parallel to the Greenland coast, and the whole length thus indicated is over 1300 miles. Iceland and Jan Mayen being volcanic, it may be that the whole range is volcanic in nature or origin—an off-shore volcanic range. The line of this chain of elevations, moreover, if continued southwestward, passes just outside of Newfoundland and the Atlantic border of the United States.

7. *Journal of the American Electrical Society, including Original and selected papers on Telegraphy and Electrical Science.* Vol. I, No. 1. 100 pp. 8vo, with several wood-cuts. Chicago: 1875. Published for the American Electrical Society.—A new, handsomely printed journal, devoted to electrical discoveries, and the various practical applications of electricity. The first paper is on the transmission of musical notes telegraphically, by Elisha Gray. The author closes with the statement that, "by this method, not only may different messages be sent simultaneously, but a tune with all its parts can be distinctly audible at the receiving end."

APPENDIX.

ART. XVIII.—*Principal Characters of the Dinocerata;* by O. C. MARSH. With five plates.

THE huge Eocene mammals, discovered by the writer in 1870, and subsequently placed in the new order *Dinocerata*, prove to be a well marked group of much interest. The Yale College Museum now contains remains of more than a hundred individuals, some of them in such excellent preservation that few points in the osseous structure of these animals need longer remain in doubt. It is proposed, therefore, to give, in the present communication, the more important characters of the members of this order, reserving the detailed description for a separate memoir. Although several distinct genera of *Dinocerata* are now known, as shown below, the typical characteristics of the group are best seen in *Dinoceras*, and hence I describe first that genus, which is especially illustrated in the accompanying plates.

DINOCERAS Marsh, 1872.*

The skull in *Dinoceras* is long and narrow, the facial portion being greatly produced. The basal line, extending from the lower margin of the foramen magnum along the palate to the end of the premaxillaries, is nearly straight. The top of the skull supports three separate transverse pairs of osseous elevations, or horn-cores, which form its most conspicuous feature, and suggested the name of the genus. The smallest of these protuberances are situated near the extremity of the nasals; a second much larger pair rise from the maxillaries in front of the orbits; while the largest are on the parietals, and supported by an enormous crest, which extends from near the orbits entirely around the lateral and posterior margins of the true cranium. (Plate II.) The posterior crest, which curves upward and backward beyond the occipital condyles, is mainly composed of the supra-occipital. The floor of the deep depression in front of this crest is formed by the parietals. These bones also send up the lateral crests. The top of the skull between the orbits is formed of the frontal bones, which are remarkably short. Their superior sutures with the parietals pass just in front of the lateral crest, and then converge posteriorly. There is no postorbital process, but in some species of

* This Journal, iv, 343, v, 117, 293 and 310.

the genus there is a prominence on the frontal, directly over the orbit. The nasals are greatly elongated, being nearly half the length of the entire skull. They unite with the frontals by oblique sutures, directed backward and inward, and nearly parallel with the superior fronto-parietal sutures. (Plate II, figure 3.) The osseous protuberances on the extremities of the nasals are of moderate size in *Dinoceras*, but, like the maxillary horn-cores, vary much with age. Both may possibly have been covered with thick skin, and not with true horns.

The orbit is large, and confluent with the temporal fossa. The latter is of great extent posteriorly, but the zygomatic arches are only moderately expanded. The squamosal forms the lower portion of the temporal fossa, and sends down a massive post-glenoid process, which bounds in front the external auditory meatus. The latter has for its posterior border the post-tympanic process of the squamosal, which unites directly with the paroccipital, thus excluding the mastoid from the external surface of the skull, as in *Rhinoceros*. The tympanic portion of the periotic, also, does not reach this surface. There are small air-cells in the walls of the temporal fossa, both in the squamosal and parietals. The squamosal sends forward a strong zygomatic process, which resembles that in *Tapirus*. The malar completes the anterior portion of the arch, extending to the front of the orbit. (Plate II, figure 1.) The lachrymal is large, and forms the anterior border of the orbit. It is perforated by a large foramen. The maxillaries are massive, and quite remarkable in supporting a pair of stout, conical horn-cores, which vary in form and size in different species. These cones are solid except at the base, which is usually perforated for the fang of the canine tusk. The premaxillaries are elongated, and without teeth. They unite posteriorly with the maxillaries just in front of the canine, and then divide, sending forward two branches, which partially enclose above and below the lateral portion of the narial aperture. (Plate II, figure 1.) The lower portion is slender, and resembles the premaxillary of some Ruminants. The premaxillaries are not united at their extremities. The latter are rough, and probably supported a pad.

The palate is very narrow and deeply excavated, especially in front. The anterior palatine foramina are in the premaxillaries, and vary much in different species. In *D. mirabile* they are elongated fissures, enclosed between the lateral and palatine branches of the premaxillaries, as in *Equus*. In *D. laticeps* they are of small size, and oval in outline. The posterior palatine foramina are in the maxillaries near the anterior border, as in *Hippopotamus*. The posterior nares extend forward between the last upper molars. The occipital condyles are large, and bounded externally in front and below by a deep groove. They

project downward and backward, showing that the head was declined when in its natural position. The exoccipitals are perforated by a condylar foramen of moderate size, which is separated from the larger foramen lacerum posterius by a slender partition of bone. Between the post-glenoid process and the basi-sphenoid, there is an irregular cavity filled in part below by the periotic. There is a distinct alisphenoid canal, and the foramen ovale is near its posterior orifice. In front of its anterior opening, is a small foramen lacerum anterius, and further forward, the optic foramen. The infraorbital foramen is large, and partially concealed behind the maxillary ridge which supports the malar.

The brain cavity in *Dinoceras* is perhaps the most remarkable feature in this remarkable genus. It proves conclusively that the brain was proportionately smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. It was, in fact, the most reptilian brain in any known mammal. In *D. mirabile*, the entire brain was actually so diminutive that it could apparently have been drawn through the neural canal of all the presacral vertebræ, certainly through the cervicals and lumbars. The size of the entire brain as compared with that of the cranium is well shown in the accompanying cut, figure 1.

1.

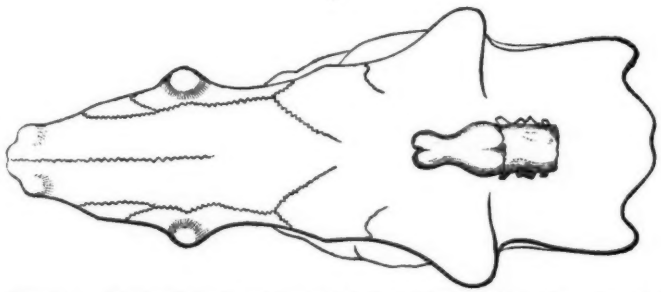


Figure 1. Outline of Skull and Brain Cavity of *Dinoceras mirabile*. Top view; one-eighth natural size.

The most striking feature in the brain cavity itself is the relatively small size of the cerebral fossa, this being but little larger than the cerebellar portion. This is shown in Plate IV, the figures of which are drawn from a cast of the brain cavity of *D. mirabile*, the type of the genus. The cerebral hemispheres did not extend at all over either the cerebellum or the olfactory lobes. The latter were large, and continued well forward. The hemispheres were apparently convoluted, and the Sylvian fissure distinctly marked. There was a rudimentary

tentorial ridge. The cerebellar fossa is but little larger transversely than the medullar canal, and has lateral cavities which may have been occupied by flocculi. The pituitary fossa is nearly round, and of moderate depth. There are no clinoid processes. The brain as a whole resembled that in some Marsupials more than in any other known mammals. Its small size, as the writer has elsewhere shown, is a character apparently pertaining to all Eocene mammals;* the brain-growth during the rest of the Tertiary period having been gradual, and mainly in the cerebrum.

The teeth in *Dinoceras* are represented by the following formula:

$$\text{Incisors } \frac{0}{3};\ \text{canines } \frac{1}{1};\ \text{premolars } \frac{3}{3};\ \text{molars } \frac{3}{3};\ \times 2 = 34.$$

The superior canines are long, decurved, trenchant tusks. They are covered with enamel, and their fangs extend upward into the base of the maxillary horn-cores. There is some evidence that these tusks were small in the females. Behind the canine, there is a moderate diastema. The molar teeth are very small. The crowns of the superior molars are formed of two transverse crests, separated externally, and meeting at their inner extremities. The series is well shown in Plate III, which represents the upper premolars and molars of *D. mirabile*. The first true molar is smaller in this specimen than the two preceding premolars. The last upper molar is much the largest of the series.

The lower jaw in *Dinoceras* is as remarkable as the skull. Its most peculiar features are the posterior direction of the condyles, hitherto unknown in Ungulates, and a massive decurved process on each ramus, extending downward and outward below the diastema. (Plate V.) The position of the condyles was evidently necessitated by the long upper tusks, as, with the ordinary ungulate articulation, the mouth could not have been fully opened. The low position of the condyle, but little above the line of the teeth, is also a noteworthy character. The long pendant processes were apparently to protect the tusks, which would otherwise be very liable to be broken. Indications of similar processes are seen in *Smilodon*, and some other Carnivores with long upper canines. With the exception of these processes, the lower jaw of *Dinoceras* is small and slender. The symphysis is completely ossified. The six incisors were contiguous, and all directed well forward. Just behind these, and not separated from them, was the small canine, which had a similar direction. The crowns of the lower molars have transverse crests, and the last of the series is the largest. (Plate V, figure 3.)

The vertebræ in *Dinoceras*, in their main characters, resemble

* This Journal, viii, p. 66, July, 1874.

those of Proboscidians. The atlas and axis are very similar to those of the elephant, but the rest of the cervicals are proportionally longer. The dorsal and lumbar vertebræ have the articular faces nearly flat, and the lumbars have an inferior ridge on the median line. There are four sacral vertebræ, the last being quite small. The anterior caudals have long, depressed, transverse processes. The ribs resemble those in *Mastodon*. The segments of the sternum were well ossified, and most of them were flattened vertically.

The scapula, in its general form, is similar to that of the elephant, but there is much less constriction above the glenoid fossa. The latter is elongate, deeply concave longitudinally, and nearly flat transversely. The spine extends downward nearly to the glenoid border. The coracoid portion is a rugose protuberance, separate from the margin of the articular fossa. The humerus is short and massive, and in its main features resembles that of the elephant. One of the most marked differences is seen in the great tuberosity, which does not rise above the head, and is but little compressed. The condylar ridge, moreover, of the distal end is tubercular, and not continued upward on the shaft. The lower extremity of the humerus is much like that of the rhinoceros, and the proportions of the two bones are essentially the same. The radius and ulna are nearly of the same size. The head of the radius rests on the middle of the ulnar articulation, and hence the shaft of this bone does not cross that of the ulna so obliquely as in the elephant. The ulna has a small face for articulation with the lunar, as in the elephant.

There are five well developed toes in the manus, which is well shown in Plate VI, figure 2. The carpal bones are eight in number, and form interlocking series, as in Perissodactyls. The scaphoid resembles that bone in the elephant, but is shorter and stouter. Its proximal end is rounded, forming about one-fourth of a sphere. On its distal end, the articular faces are confluent. It supports the trapezium and trapezoid. The pyramidal sends down an outer angle to articulate with the fifth metacarpal, as in *Elephas*. The trapezoid is the smallest bone in the carpus. The magnum is supported by the lunar, and not at all by the scaphoid. The unciform is the largest carpal bone. It has the usual metacarpal faces well marked, and separated by ridges. The metacarpals are of moderate length, and the third is about equally supported by the magnum and unciform. The articulations for the phalanges are nearly flat, indicating but little motion. The phalanges are very short, and the distal ones rugose.

The pelvis is much expanded, as in Proboscidians. The ilium is suboval in outline. The pubis is slender and short,

and the ischium has less posterior extension than in the elephant. The thyroid foramen is an elongate oval. The femur is proportionally about one-third shorter than that of the elephant. The head of this bone has no pit for the round ligament, and the great trochanter is flattened and recurved. There is no indication of a third trochanter. The distal end of the femur is more flattened transversely than in the elephant, and the condyles are more nearly of the same size. The corresponding articular faces of the tibia are consequently about equal, and also contiguous, with no prominent elevation between them. When the limb was at rest, the femur and tibia were nearly in the same line, as in the elephant and man. The patella is elongate, and oval in outline. The fibula is slender, and entire, with articular faces well marked at each extremity. The astragalus has no distinct superior groove. Its anterior portion has articular faces for both the navicular and cuboid, thus differing from Proboscidians, and agreeing with Perissodactyls. The calcaneum is very short, its longitudinal and transverse diameters being about equal. It does not articulate with the navicular, as in *Elephas*, and has only a small face for the cuboid. There are four well developed digits in the pes, and a rudimentary or small hallux. The metatarsals are much shorter than the metacarpals. The phalanges and sesamoid bones are smaller, but otherwise similar to those of the manus. The hind foot is shown in figure 1 of Plate VI. None of the bones of the skeleton are hollow.

The known species of *Dinoceras* nearly equalled the elephant in size, but the limbs were shorter. The head could reach the ground, and there is no evidence of a proboscis. All the remains of the genus yet discovered are from the Eocene of Wyoming.

Yale College, New Haven, Jan. 18th, 1876.

(To be continued.)

Explanation of Plates.

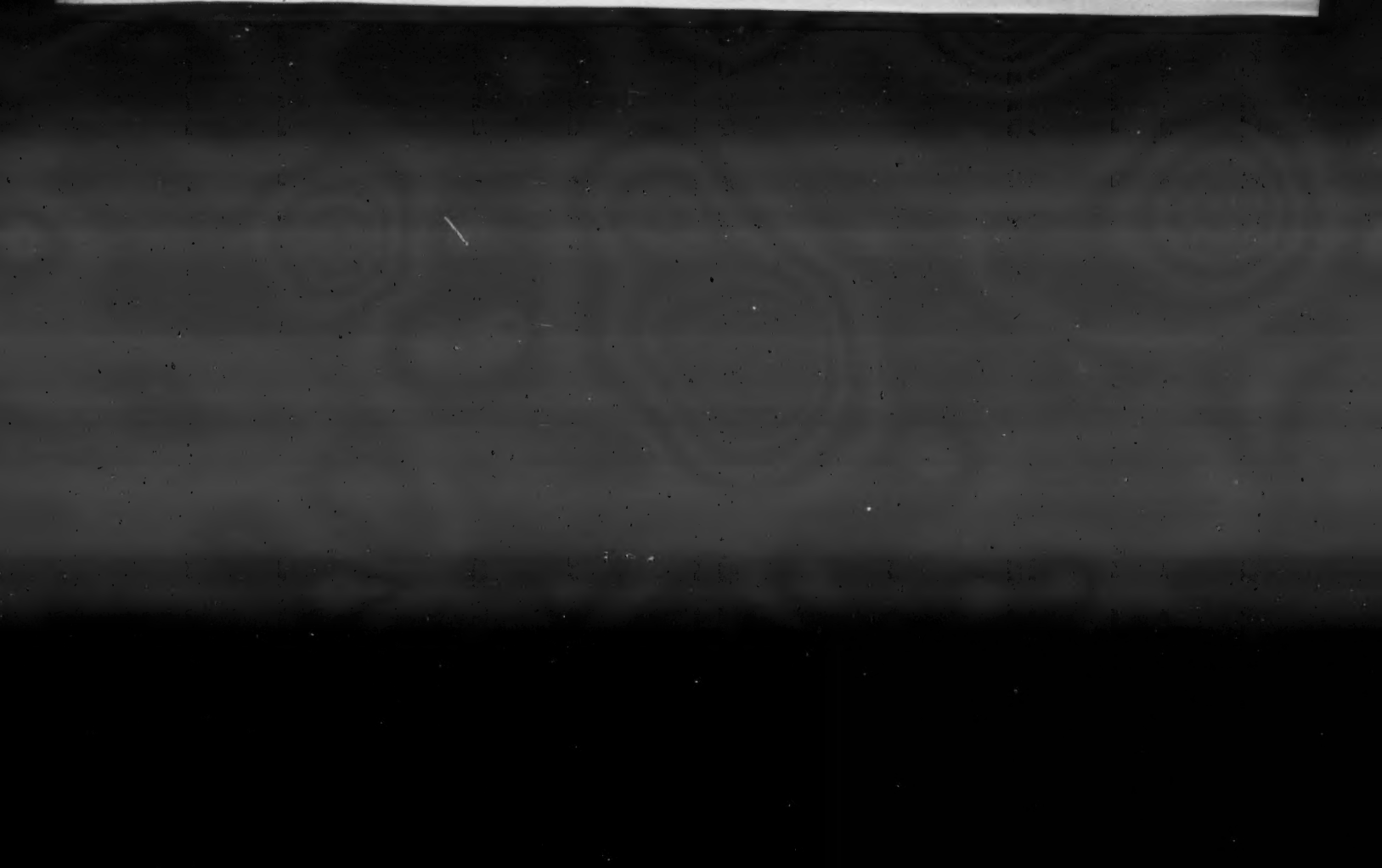
Plate II.—*Dinoceras mirabile* Marsh. Figure 1, side view of skull; figure 2, front view; figure 3, top view. One-eighth natural size.

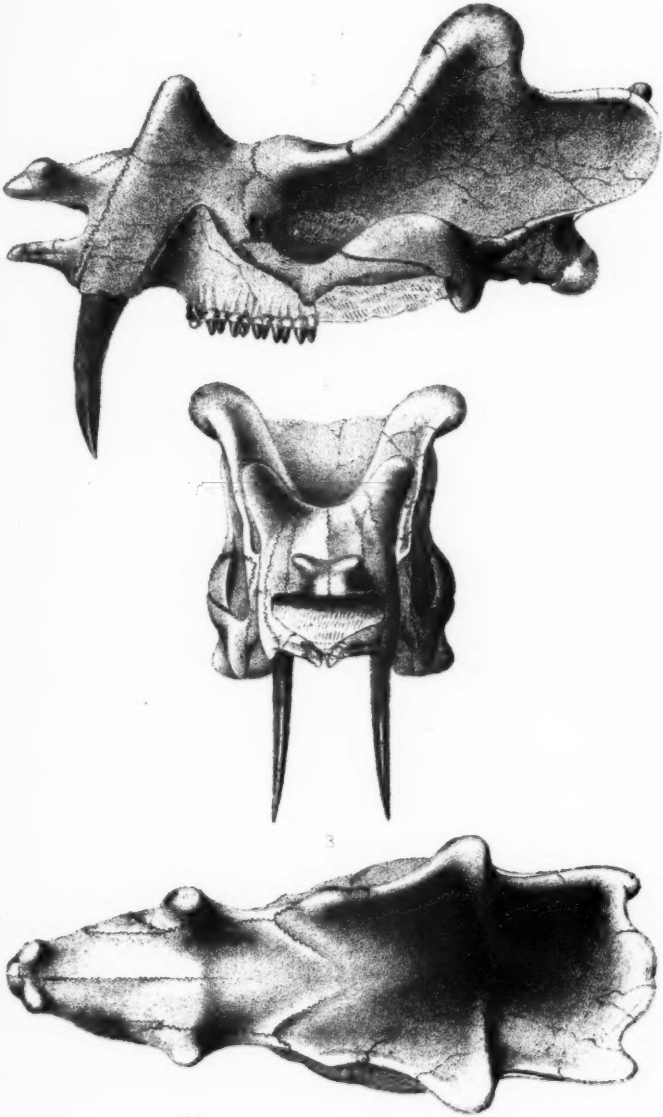
Plate III.—*Dinoceras mirabile.* Superior premolar and molar teeth; bottom view. Three-fourths natural size.

Plate IV.—*Dinoceras mirabile.* Cast of brain cavity. Figure 1, side view; figure 2, top view; figure 3, bottom view. One-half natural size.

Plate V.—*Dinoceras laticeps* Marsh. Lower jaw. Figure 1, front view; figure 2, side view; figure 3, top view. One-fifth natural size.

Plate VI.—*Dinoceras.* Figure 1, hind foot; figure 2, fore foot. One-third natural size.





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DINOCERAS MIRABILE Marsh

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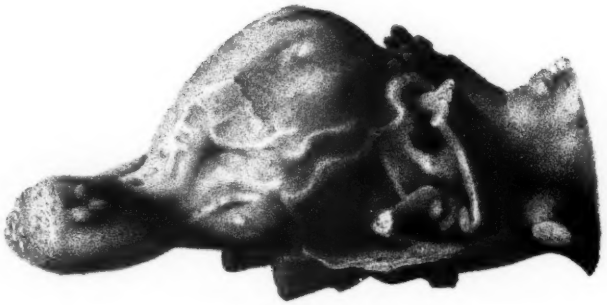

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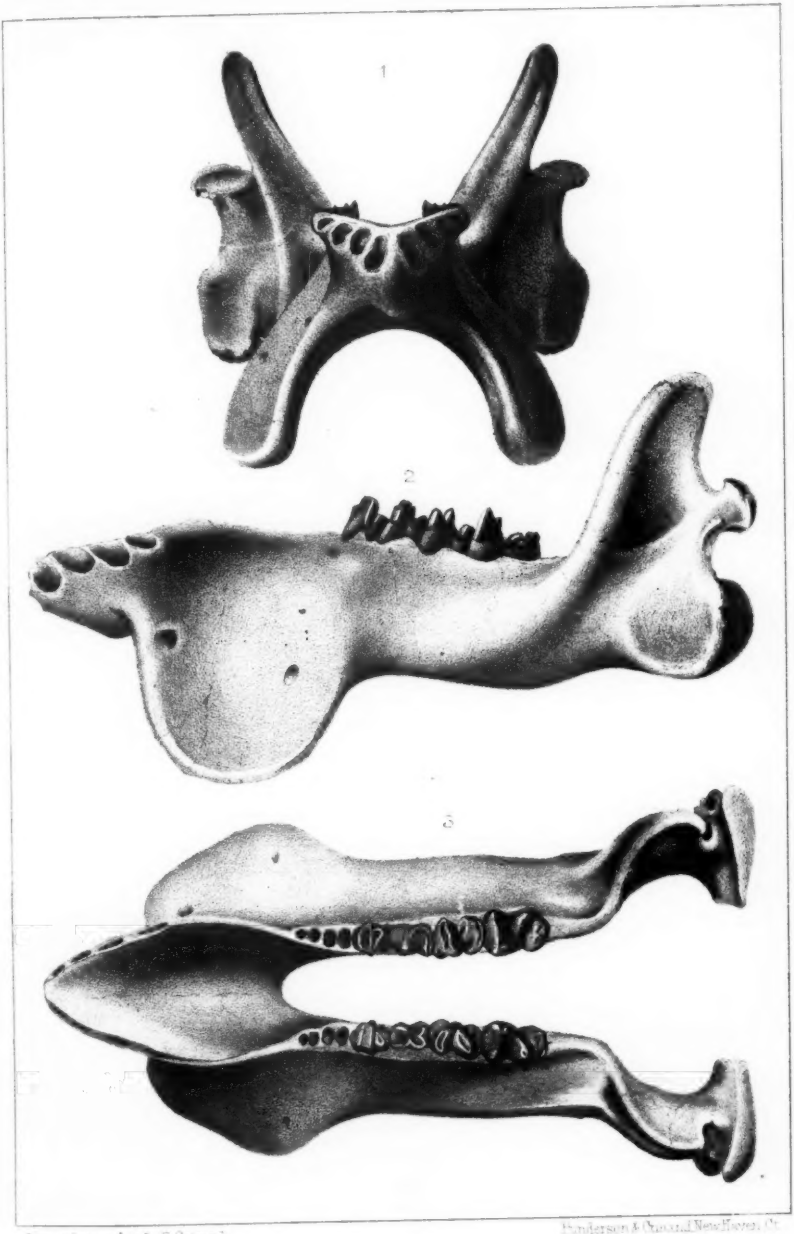
LINOCEFAS MIRABILE, Marsh



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DINOCERAS LATICEPS Marsh 1/6

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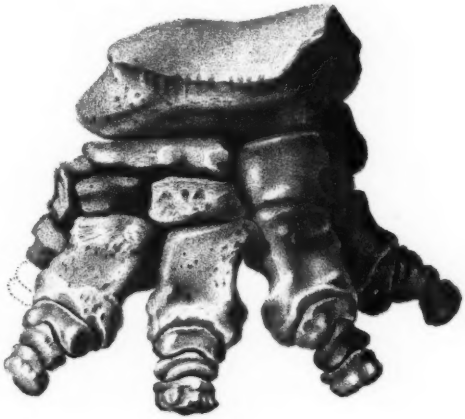

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DINOCERAS 1/8